ted States
partment of
riculture

Forest Service

**Intermountain
Forest and Range
Experiment Station**

General Technical
Report INT-109

March 1981

Proceedings of Intermountain Nurseryman's Association and Western Forest Nursery Association

Combined Meeting

**August 12-14, 1980
Boise, Idaho**

PESTICIDE PRECAUTIONARY STATEMENT

This publication reports research involving pesticides. It does not contain recommendations for their use, nor does it imply that the uses discussed here have been registered. All uses of pesticides must be registered by appropriate State and/or Federal agencies before they can be recommended.

CAUTION: Pesticides can be injurious to humans, domestic animals, desirable plants, and fish or other wildlife--if they are not handled or applied properly. Use all pesticides selectively and carefully. Follow recommended practices for the disposal of surplus pesticides and pesticide containers.

PROTECT

Use Pesticides Safely

FOLLOW THE LABEL

U.S. DEPARTMENT OF AGRICULTURE

United States
Department of
Agriculture

Forest Service

**Intermountain
Forest and Range
Experiment Station**

General Technical
Report INT-109

March 1981

Proceedings of Intermountain Nurseryman's Association and Western Forest Nursery Association

Combined Meeting

**August 12-14, 1980
Boise, Idaho**

Hosted by:

U.S. Department of Agriculture
Forest Service
Boise National Forest
Lucky Peak Nursery

Proceedings Published by:

Intermountain Forest and Range Experiment Station,
Forest Service,
U.S. Department of Agriculture

CONTENTS

"WELCOME"

by

Ralph Peinecke
Vice President Timberland Resources
Boise Cascade Corporation

for the

Joint Meeting
Intermountain Nurseryman's Association
Western Forest Nursery Council

Boise, Idaho
August 12, 1980

Thank you, Dick, and good morning ladies and gentlemen. I appreciate the opportunity to take part in the combined meeting of these two organizations, whose work is so important to us all.

To those of you from other regions of the country, Canada and elsewhere, I would like to welcome you to Boise and to the Intermountain West. While your agenda over these three days is a busy one, I trust you'll be able to enjoy our community and Southwestern Idaho. Although Boise Cascade Corporation has grown over the years to touch many parts of North America, the company's roots are here in the Intermountain West, and we're very proud of it.

As the opening year of a new decade, this seems like an appropriate time to stop and look at where we are, and see what the future holds for forestry. As a matter of fact, the National Forest Management Act requires that we do just that.

As this nation charts its future for managing our abundant timberlands, a point which the American philosopher Will Durant left us with is worth repeating. Durant observed that "At 20, I knew everything and my father knew nothing. But when I was 30, I was surprised to see how much my father had learned during the past 10 years."

As I look back, I can relate to what Durant was saying. I'm sure you can too.

In growing the timber for a whole spectrum of forest products which have contributed so much to society over the past 200 years, and has helped raise our standard of living to unprecedented heights, we have learned a lot about growing trees. Especially in the past 20 to 30 years, forest management has advanced dramatically. Developments in genetics research, mechanization, computer sciences and other technologies have brought about quantum gains in our ability to increase the potential productivity of timberlands for many uses.

In looking over the agenda for this seminar a few days ago, I was impressed by the range and depth of subjects to be covered here. The information to be exchanged will certainly be valuable. It must be, because each of us here today is faced with a very major challenge. Today's and tomorrow's forests must provide for dramatically increasing social and economic needs. Domestic demand for paper and wood products, according to the Forest Services's Resource Planning Act assessment, will more than double within the next 50 years.

Between 1976 and the year 2030, demand will rise from 13.3 billion cubic feet to 28.7 billion cubic feet. And largely, with the exception of the shorter crop rotation areas of the South, it will be the trees already in the ground today that must meet this need. And it is to the credit of those in the audience that many of those trees in the ground today that will help sustain this harvest were developed in your nurseries.

If I sound concerned about this challenge, I want you to know that in fact, I am. On the one hand, the expanse and productive potential of this nation's forests is so great, that not only can the public demand be met, but, at the appropriate time, the U.S. could become the world's wood products basket, the major supplier to other nations of building materials paper and related products. But ironically, we know that present levels of forest management are inadequate.

Forests comprise about one-third of the U.S. land mass. Of these timberlands, about 500 million acres are classified as commercially productive. And of these commercial acres, more than half are almost totally unmanaged.

Industry owns 14 percent of this commercial timberland base, and provides 37 percent of the nation's softwood fiber supply. The federal government controls 20 percent of the U.S. commercial timberland base but only supplies 23 percent of the harvest. The remaining 40 percent of the harvest comes from the 66 percent of the resources held by the non-industrial private and other public ownerships.

With only 16 percent of the U.S. commercial timberland base, the forest industry accounts for over 50 percent of new tree planting and direct seeding; 50 percent of timber stand improvement carried out on non-federal land, and produces more than 40 percent of the tree nursery stock.

In Oregon and Washington alone, industrial nursery capacity has grown from 26 forest tree nurseries in 1973 to 53 nurseries operated today by the Industrial Forestry Association and other private interests. Annual capacity in these nurseries now totals more than 300 million trees, of which 60 million are container production. And on all industrial lands in Oregon and Washington, the forests being replanted each year exceed the number of acres being clearcut harvested by some 10,000 acres -- and this planting trend is increasing.

As a result of these and other efforts, the annual growth of timber on industry lands is closer to full production potential than on lands in any other ownership classification. Certainly, the commercial forest areas on the National Forests must be managed for objectives beyond timber production alone. But it has been clearly demonstrated that greater fiber productivity is compatible with increased recreation opportunities, wildlife propagation and clear waters. A very good example of this is the Big Creek salmon and steelhead hatchery located just downstream from some Boise Cascade timberlands in northwest Oregon. The story of this timber shed and fish hatchery is featured in a magazine called the BOISE CASCADE QUARTERLY. For those interested, copies of the QUARTERLY and a descriptive brochure called BOISE CASCADE FORESTS are available on the literature table.

Meeting the challenge of increasing fiber demand will take a combination of time, money, silvicultural know-how and responsible management by government, industry and the private non-industrial sector. If money grew on trees, our problems would be over. But the reality is that trees grow on money, hence, substantial investments must be made to achieve greater forest productive potential including increased investments in forest nurseries and nursery research. That money must be backed up by a lot of faith and conviction, since the focus of timber investment is very long-term.

A major trade association estimates that industry, for example, must generate more than $3 billion dollars annually to cover all necessary costs of acquisition, reforestation, maintenance, silviculture, taxes, interest, roads and other management aspects. Adequate levels of investment also are needed on private non-industrial and government lands to bring them up to the needed levels of fiber growth and yield.

Investment in the private sector -- both industrial and non-industrial -- can be encouraged by far-sighted, responsible regulation and legislation. Excessive restrictions and taxation levels that discourage needed investments will do nothing to avert a wood fiber shortfall. The national economy, and ultimately, the American consumer, will be the losers. This just isn't necessary.

Certainly, it is highly important to address the growing of new trees. And it is equally necessary to address ourselves to the need for responsible management of existing forests, including control of destructive pests such as the gypsy moth, the pine bark beetle, the tussock moth and the spruce budworm that has heavily infested large acreages in this and other regions and absolutely must be controlled.

Having the tools to practice silviculture is critical to responsible forest management. I'm highly concerned that we are losing necessary tools such as pesticides and herbicides that are proven to be safe and effective, without having developed suitable replacements for these forest chemicals.

In recent years, through work being done by organizations and individuals such as those of you here today, we have truly begun to understand that we can manage and control the volume, qualities, and form of wood fiber and its many products. Based on the promise of new research and development, forest management programs of the year 2000 might make some of today's practices look rudimentary by comparison.

To see that this potential to provide fiber can be realized, here are some things that I would <u>ask</u> you to do beyond the work that you're presently involved in:

- o Work to promote understanding of the fact that government, industry, private landowners and conservationists should be allies in forest management. It is time to accentuate the positive by firmly establishing common areas of agreement instead of adding to the cycle of action and reaction.

- o Second, be vocal about the need for government and its regulatory agencies to improve the climate for capital investment in timber productivity. Let's encourage investment that is in the public interest.

- Next, give vigorous support at all levels of government to legislation promoting wise use of national resources. A good place to start on this is to give active support to the release of productive commercial forest lands that were studied in the Forest Service's Roadless Area Review and Evaluation but <u>not</u> recommended for wilderness designation.

Through these public policy actions, we can contribute even more to the shaping of the future of forestry. There was never a more important time for it.

I'd like to leave you with a thought often expressed by Boise Cascade's chief forester. He says it is a lot of fun to manage a big, thriving second growth forest because you can play the role of a physician. But if you're managing an overmature old-growth forest, you're somewhat akin to a mortician.

Most of us in this profession, I'm sure, would rather be the physician. In fact, those of you in the audience might think of yourselves as being somewhat of a pediatrician. It all starts with the work you're doing. Having brought the baby into the world, none of us wants to leave it out there to perish.

Thanks for this opportunity to be with you today. I'm sure that you will have a very successful seminar here in Boise.

EMERGING RESOURCE TRENDS IN THE 80'S[1]

R. Max Peterson, Chief[2]

Nothing is more universally expected of a forestry agency than that it be able to plant and grow high-quality trees. Our future timber supply is directly connected to the sufficiency of our reforestation effort. Most other values of the forest--wildlife, water supply, beauty--are connected with adequate forest cover. So, it is appropriate that we are commemorating the Forest Service's 75th anniversary with a tree-planting campaign.

You know the trends as described in our RPA Assessment--more people, more disposable income, more leisure time, and greater demands on the forests. These trends have already shaped nursery management--there are more nurseries, larger nurseries, more seed sources, speeded-up seedling production, and more sophisticated cultural practices. It is gratifying to look at the nurseries developed in the past two decades--much progress has been made in nursery practices. This progress is one of the key ingredients to the gains we have made in long-term forest growth.

But, more must be done if we are to meet the demands continuing to press on public and private forest lands alike. First, the demand for high quality planting stock will continue to grow. A recent legislative expression of our concern for reforestation is the NFMA's requirement that we budget to eliminate the feasible reforestation backlog on National forests by 1985. By October of 1979, we had reduced the backlog from 3.1 million acres to 882,000 acres--half by actual reforestation, a quarter by land reclassification, and a quarter through natural regeneration. Of this remainder, it is feasible to reforest about 566,000 acres and the proposed budget level for 1981 is sufficient to stay on the schedule of removing this backlog by 1985 if adequate funds are provided in future years. In all cases, we will need first-rate planting stock.

We are expanding our nursery capacity--our estimates show a need for about 269 million seedlings from Forest Service nurseries over the next several years. This will meet our needs as well as those of BLM and other cooperators. There is a huge reforestation job ahead on private lands, too. In the Pacific Northwest and coastal Alaska, more than 75 percent of the nonstocked lands are on highly productive sites. We are particularly concerned about the amount of private, nonindustrial forest land in the South that is not reforested after harvesting--over a 10-year period, 7 million acres of pine forest were replaced by less desirable species or remained essentially unstocked. Our long-term program will provide assistance to motivate landowners to reforest and to use genetically-improved stock. Our goal is to nearly quadruple the amount of private-land reforestation each year. We are working with the Dept. of the Treasury to analyze tax incentives to encourage landowners to reforest their lands.

---

[1] Speech presented at Intermountain Nurseryman's Association, Western Forest Nursery Council, Joint Meeting, Boise, Idaho, August 12/13/14, 1980.

[2] Chief, R. Max Peterson, USDA Forest Service, Washington, D.C. 20013

A second trend is the growing complexity of nursery work--tailoring seed sources and seedling characteristics to site requirements and to meet the diverse needs of wildlife, esthetics and energy production. The complexity of nursery work will probably prompt increased computerization, greater specialization and the growth of Nursery staffs. Third, nursery management is becoming world-wide in scope--nurserymen search the globe for the materials or knowledge needed to improve forest in their own nations.

A fourth trend is the growing importance of nursery research and the application of research results. Research can help develop cost-saving cultural practices or equipment, or ways to protect expensive plant materials from insects, disease or other damage. Conferences such as this are immensely valuable in getting this research knowledge into practice.

The trends of growing demand for the quantity and quality of seedlings, the increased complexity of nursery work, broadening international interest, and continuing scientific progress add up to a decade of immense opportunity and challenge.

CANADIAN NURSERY UPDATE[1]

Ralph F. Huber[2]

INTRODUCTION

The 1981 meeting of the Intermountain Nurserymen's Meeting will be held in Edmonton, Alberta, Canada, August 11 - 13. Many of you will be attending your first Nurserymen's Meeting outside of the United States. In order to acquaint you with the nurseries you could visit in Canada, I will outline nursery production first on a national basis and then in detail for the western and northern region in which Alberta is located.

NATIONAL SUMMARY

Bare-Root Seedling Production

In 1979, approximately 205 million bare-root seedlings were shipped from 46 production centres across Canada to the field for reforestation and afforestation purposes (Table 1).

Table 1.--National summary of bare-root seedling production

Province	No. of production centres	Area available for production (ha)	Area currently in production (ha)	Production 1979 ('000)
British Columbia	8	806	278	66,730
Alberta	2	193	99	3,400
Saskatchewan	5	308	219	16,230
Manitoba	1	19	4	1,432
Ontario	12	693	536	62,370
Quebec	10	284	176	30,875
New Brunswick	3	166	147	20,300
Nova Scotia	2	98	18	2,900
Prince Edward Island	1	34	0.4	300
Newfoundland	2	245	42	300
	46	2,846	1,517	204,837

[1]Paper presented at the combined meeting of the Western Nursery Council and Intermountain Nursery Man's Association, Boise, Idaho, August 12-14, 1980.
[2]Nursery Production, Northern Forest Research Centre, Canadian Forestry Service, Edmonton, Alberta, Canada.

Production for 1980 is estimated at 228 million seedlings, an increase of approximately 11% over 1979.

Containerized Seedling Production

In 1979, 108 million containerized seedlings were shipped in a variety of container types from 47 production centres across Canada (Table 2).

Table 2.--National summary of containerized seedling production

Province	No. of production centres	Production 1979 ('000)	Heated (No.)	Heated (Area m^2)	Non-heated (No.)	Non-heated (Area m^2)
British Columbia	10	34,307	73	28,608	19	7,812
Alberta	5	20,620	35	17,343	-	-
Saskatchewan	2	1,860	3	1,180	-	-
Manitoba	1	645	4	622	-	-
Ontario	8	10,240	22	5,361	16	4,067
Quebec	3	772	6	1,277	-	-
New Brunswick	9	32,312	46	21,135	7	4,670
Nova Scotia	6	5,946	14	4,322	18	4,918
Prince Edward Island	1	1,200	1	1,860	-	-
Newfoundland	2	556	4	1,168	-	-
	47	108,458	208	82,876	60	21,467

Shipments for 1980 are estimated at 124 million seedlings, an increase of approximately 14% over 1979.

Currently, Canada has 104,343 m^2 of growing area available for the production of containerized stock in federal, provincial, industrial and private greenhouse facilities. Seventy-nine (79%) percent of this area is in 208 heated greenhouses.

The popularity of container types used varies across the country (Table 3).

Table 3.--Container types used in Canada

Province	Container Type
British Columbia	-BC/CFS Styroblock 2A and 4 -Spencer-Lemaire 'Fives' Rootrainers
Alberta	-Spencer-Lemaire 'Ferdinand', 'Fives' and 'Hillsons' Rootrainers
Saskatchewan	-FH 408 Japanese Paperpot -FH 315 & FH 408 Japanese Paperpot
Ontario	-FH 408 Japanese Paperpot -Spencer-Lemaire 'Ferdinand' Rootrainer

Quebec	-BC/CFS Styroblock 2A and 4 -Spencer-Lemaire Rootrainers
New Brunswick	-FH 408 Japanese Paperpot -Can-Am 45 cc Multipot
Nova Scotia	-FH 408 Japanese Paperpot -Can-Am 80 cc Multipot
Prince Edward Island	-Spencer-Lemaire 'Ferdinand' Rootrainer
Newfoundland	-FH 408 Japanese Paperpot -Spencer-Lemaire 'Fives' Rootrainer -Can-Am 43 cc Multipot

WESTERN AND NORTHERN REGION

Within the region there are eleven facilities producing bare-root seedlings, container seedlings, or a combination of both, for reforestation or afforestation (fig. 1). Production at different nurseries varies from twenty million to two hundred and fifty thousand. Table 4 gives a regional production summary.

Figure 1.--Location of Nurseries in the Western and Northern Region.

Table 4.--Western and Northern Region summary of nurseries

	Bare-root	Container
Number of Production Centres	8	8
Area Available for Production	520 ha	19,145 m^2
Area Currently in Production	322 ha	19,145 m^2
1979 Production ('000)	21,062	23,125
Estimated 1980 Production ('000)	30,150	22,060
Number/Area Heated Greenhouses		42/19,145 m^2

HI-LITES OF SELECTED NURSERIES

Some of the nurseries within the region have unique systems or machinery for accomplishing certain tasks. They are as follows:

Nursery	Unique characteristics
Pineland Provincial Forest Nursery Hadashville, Manitoba	Rolling greenhouses--when one crop of seedlings is ready to be moved out, they roll greenhouse to new location and start second crop.
PFRA Tree Nursery Indian Head, Saskatchewan	Highly mechanized. Assorted seeds for different species. Good lifting system. Modern cold storage.
Prince Albert Forest Nursery Prince Albert, Saskatchewan	Large glass greenhouses. Automatic boom sprinklers. Complete paperpot filling system. New seed extraction plant.
Pine Ridge Forest Nursery Smoky Lake, Alberta	Very modern facility. Twenty (20) greenhouses. Pallet system for containers. Tree breeding facility. Automatic filling system for containers. Seed extraction plant.
Provincial Tree Nursery Oliver, Alberta	Growing many different species in containers. Propagation trials.
Simpson Timber (Alta.) Ltd. Whitecourt, Alberta	Container Production Greenhouse with travelling boom for both water and lights.
St. Regis (Alberta) Ltd. Hinton, Alberta	New glass container production facility. Set up to grow 12 crops of 240 m each per year.

FORESTATION CONCEPTS AND PRACTICES

DEVELOPING IN NEW ZEALAND[1]

Richard W. Tinus[2]

In New Zealand government and industry are developing a new nursery system backed by substantial research facilities and budget. Beds of radiata pine are precision sown and thinned to square spacing of 7 x 7 cm. This permits "box pruning" which is horizontal undercutting plus vertical root pruning along and across the bed. When lifted, a box-pruned seedling retains virtually all of its roots, and almost every tree is shippable. Since culling and counting are not necessary seedlings can be lifted and packed in the field, eliminating the need for a packing shed. Reduction in exposure and handling of seedlings increases plantation survival and initial growth, and promises to reduce rotation age by 1 year and decrease nursery costs.

Radiata pine of all ages has been successfully propagated from cuttings.

In August 1979, I attended an International Union of Forestry Research Organizations workshop in New Zealand on "Techniques for Evaluating of Planting Stock Quality." I toured facilities where new concepts and products in forestation are being developed to meet New Zealand needs. Some of these practices seem applicable in this country.

New Zealand currently has about 750,000 h of planted radiata pine. This single, introduced species has become the major basis of New Zealand wood production for domestic consumption and export. Radiata pine is very fast growing in New Zealand, with a first thinning and pruning at age 7 and a rotation age of between 27 and 30 years. Final tree sizes are 60 cm in diameter and 30 m tall. On the best New Zealand sites, radiata pine reaches 40 m in 20 years. Because of New Zealand's distance from major international markets, New Zealanders need to raise trees very cheaply and efficiently. Hence, they invest a great deal of money and manpower in forestry research.

Slide 1. The federal Forestry Research Institute at Rotorua is engaged in many projects, but a great deal of effort is spent improving nursery practices. This is the only nursery I know of devoted solely to research.

---

[1] Paper presented at a joint meeting of the Intermountain Nurseryman's Association and the Western Forest Nursery Council, Boise, Idaho, August 12-14, 1980.

[2] Plant Physiologist, USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Bottineau, N. Dak.

Slide 2. New Zealanders are developing a comprehensive regeneration system which begins in the nursery and is followed through transportation, planting, and aftercare. The concept begins with square spacing in the nursery beds. This is in contrast to conventional beds in which seedlings are much closer within the row than between rows. Research at Rotorua is in progress to determine the spacing necessary to produce the desired seedling.

Slide 3. Square spacing of these seedlings increases from 3 x 3 cm to 10 x 10 cm left to right. At present, it looks as though 7 x 7 cm spacing is optimum for radiata pine. Square spacing is achieved by seeding precisely and thinning. For seeding the Ojyard[3] seeder is used, which is good, but not perfect. Of course, the seed is also good, but not perfect. After germination, the beds are thinned. This expensive hand operation has not yet been mechanized, but at the moment it is the only way to achieve square spacing.

Slide 4. The purpose of square spacing is twofold: First, it enables the seedling to make very efficient use of the available space. Second, it permits "box pruning," which is pruning the root system of each seedling on 4 sides and the bottom. Undercutting and along-the-row pruning have been mechanized, but across-the-row root pruning has not.

Slide 5. Undercutting is for the purpose of developing a fibrous and compact root system in the soil zone that will be lifted. Undercutting severs the taproot cleanly. It is done with a thin, sharp blade on a reciprocating undercutter. The blade is similar to a bandsaw blade and is changed at the end of each row. Undercutting does not lift the seedlings. When undercut at a depth of 10 cm, you can barely see the tops wiggle as the blade passes under them. All radiata pine at Rotorua is raised as 1-0, and undercutting is generally done twice, first at a 10 cm depth, and later at 12-15 cm.

Slide 6. By switching to a heavy blade and tilting it about 20°, this same machine can be used for "wrenching." The wrenching blade need not be particularly sharp, because it does not cut anything. It passes completely under the seedlings, lifts them and the soil, loosening the root to soil contact. The purpose is to stress the seedling to stop the terminal elongation and enable the seedling to better withstand subsequent stress especially after outplanting.

Slide 7. A box pruned seedling is lifted with virtually all of its roots intact in a compact volume that can be planted with little root damage. There are no long stringy roots that need to be pruned at packing to prevent a poor planting.

Slide 8. In the New Zealand climate, radiata pine behaves similarly to southern pine. That is, it can be planted successfully with comparatively few roots compared to the shoot. If you look carefully at the seedling in this slide, you can see the two levels where it has been undercut. The pencil indicates the lowermost point of undercutting. The first cut was about 5 cm above that, immediately below the major horizontal spray of roots. Seedlings are first undercut at a shallow depth and later undercut somewhat deeper.

In North America, there seems to be disagreement among nurserymen as to the value of wrenching, and I can suggest several reasons why this is the case. First, not all nurseries have the proper equipment. A reciprocating undercutter is essential

---

[3]The use of trade and company names is for the benefit of the reader; such use does not constitute an official endorsement or approval of any service or product by the U.S. Department of Agriculture to the exclusion of others that may be suitable.

for both undercutting and wrenching. Second, the soil must be suitable. The soil at Rotorua is a very friable volcanic ash soil with few rocks and very little sticky clay in it. Because of the soil, I see many difficulties in developing proper wrenching regimes at nurseries like Lucky Peak at Boise or Big Sioux Conifer Nursery at Watertown. Third, the timing of undercutting and wrenching must be in accord with the physiology of the tree. It is not possible to take the New Zealanders' schedule, transpose seasons to the northern hemisphere, and apply the schedule mechanically. Each species grown and nursery location may need research to develop an appropriate schedule.

Slide 9. A crucial aspect of the New Zealand concept is the reduction of seedling handling in the nursery, during transportation, and in storage. This has both biological and economic advantages. Having been thinned and box pruned by the time the seedlings are ready to be lifted, virtually every seedling is shippable. Thus, there is no need to grade and count them. The number of trees shipped can be computed from how many meters of bed are lifted. The seedlings can be packed in the nursery bed as they are lifted. The seedlings are packaged in rigid boxes which protect the seedlings from crushing. This eliminates broken buds and bruised tissues which release metabolites and encourage the growth of pathogens. The boxes filled with seedlings at the nursery bed are placed in insulated coolers and shipped to storage or to the field. At the planting site, the shipping box is clipped onto the planter's belt, becoming the planting box.

Slide 10. Shipping and storage containers are insulated but not refrigerated. Seedlings are not stored for more than a few weeks, often only a day or two. The weather is cool, usually cloudy, and frequently rainy during the shipping and planting season, so this method of storage has proven quite satisfactory. However, it could be readily adapted to refrigerated or frozen storage.

Slide 11. New Zealand foresters have good reason to believe that their proposed system will produce better trees in a shorter period of time. On the right side of the picture are trees produced and planted by the current operational system. That is, trees are lifted in the field, taken to a shed for culling, root-trimming, and packing into bags. Then they are stored and shipped out to the field for planting. On the left are seedlings that have been thinned, box pruned, and packed into boxes at the nursery bed and outplanted from these same boxes. Survival and growth of this group are clearly superior to those handled by the current system. This entire plantation was put in by the same planting crew.

Slide 12. Other plantings show the same comparison. These seedlings were packed in bags in the shed.

Slide 13. These seedlings were packed at the bed. Not only does the survival increase, but equally important is the increased growth that may shorten the rotation by a year.

Now with all this research, you would think that the new techniques would be quickly and readily adopted by the operational nurseries. However, as in other parts of the world, especially government operations, this is not necessarily the case.

Slide 14. Here we are at the Kaingaroa Nursery, which grows radiata pine seedlings for the Kaingaroa Forest. Notice that these seedlings do not look quite as good as the ones grown at the research nursery in Rotorua, partly because this nursery is 300 m higher in elevation and most of the stock produced is 2-0.

Slide 15. The spacing is not very uniform. The seedlings are not as large or as good in color.

Slide 16. The range of seedlings lifted at the nursery runs from excellent to just passable.

Slide 17. In the packing shed I saw much unnecessary root exposure. Fortunately, it was a cool, cloudy day.

Slide 18. After the trees are selected and bundled, the roots are pruned; thus maximizing the shock to the tree. This operation could be eliminated by box pruning.

Slide 19. The seedlings are assembled in half 15 gallon barrels,

Slide 20. And unceremoniously dumped into plastic bags,

Slide 21. Which are then moved by a rather ingenious conveyer,

Slides 22 & 23. Into a storage facility, which is well insulated, but not mechanically refrigerated.

Slide 24. New Zealand foresters do train their planters, however, and some of the devices for doing so might well be emulated. Here is a cartoon showing how to do everything wrong. I'm sure most of you already know the techniques.

Slide 25 & 26. Next, an illustration of how to do it right, starting with thinning in the nursery, packing in the bed in rigid boxes, storing the boxes in a large insulated container which is handled mechanically, and planting from the boxes at the planting site. Stress is layed on minimizing handling and exposure.

Slide 27. This is supplemented by photographs showing do's and don'ts.

Slide 28. Another aspect of raising radiata pine is that it can be propagated vegetatively.

Slide 29. Cuttings from trees under 7 years of age root readily in the field. Government and industrial foresters are using this method to extend the propagules of superior trees for commercial operations. The New Zealand climate and tree species permit this, but I doubt that it would be successful with most of the species we grow in the United States.

Old radiata pine, however, do not root readily, and rooting has all of the problems encountered with many other pine species. Researchers at Rotorua have found a way to root scions successfully, however. First, branch tips are girdled after shoot growth has been completed in mid-summer. The girdle is waterproofed with vaseline and covered with aluminum foil. This is not an air layer, however. The scion will callus at the base, but not root. At the same time, major buds are picked off the scion.

Slide 30. About 4 weeks later, after the girdle is well calloused and new small buds have developed on the terminal, the scion is cut and transferred to a small bedhouse covered with white poly. The scions overwinter unrooted. In the spring, rooting occurs, as well as bud break. After the scions appear to be established, they are lifted and the roots pruned back to within a few millimeters of the original callus, placed in jiffy pots and allowed to root again. This time they produce roots that are functional and have normal anatomy. When the roots penetrate the jiffy pots, they are considered ready to go to the field. I am testing this technique on Scotch pine and ponderosa pine, and will know in another year whether or not it will work.

Slide 31. It certainly works for radiata pine. One of these rows is from seedlings and the other is from cuttings. You can see they are equally good.

Slide 32. New Zealanders are also studying tissue culture and are at the point where cultures from cotyledons and the female gametophyte are expected to be used for operational plantings within 2 years.

Slide 33. Seedlings produced by tissue culture look normal, healthy, and very uniform.

Slide 34. Another of the facilities at Rotorua is probably the world's tallest growth chamber. There is room for a crowd of 12 people and 4 trees in a chamber 3 stories high.

Slide 35. The trees are growing in containers 3 m on a side with transparent walls, so that the roots can be inspected.

Slide 36. Another controlled environment facility is at Palmerston North--the Climate Laboratory, designed, built, and run by the Plant Physiology Division of the Department of Scientific and Industrial Research. The Forestry Institute is currently running experiments in this facility on hardiness, but the facility is available to the New Zealand scientific community in general.

Slide 37. To the greatest extent possible the machinery controlling the environment is outside the chamber.

Slides 38 & 39. The Climate Laboratory has displays showing what they can control in those growth chambers.

Slide 40. Seedlings can be subjected to both radiation and advective freezes. As a matter of fact, they can create snowstorms in this facility. Those of you who know anything about mechanical refrigeration will appreciate how difficult it is to create an event like this.

Slide 41. The Climate Laboratory now has for radiata pine curves of frost tolerance versus time of year. These are used to determine suitability of planting stock for a given site, for determining planting dates, and for tree improvement purposes.

Slide 42. The University of Canterbury at Christchurch is engaged in studies on the growth rate and potential of trees. There is a quarter of a million dollars worth of field equipment packed into two trucks and taken out to the field.

Slides 43, 44, & 45. A cuvette, for measuring photosynthesis and transpiration, is placed on the branch to be tested. Light can be added using a Xenon arc mounted on a boom.

Slide 46. The controls and data logging equipment are inside one of the trailers.

Slide 47. Not every tree planted in New Zealand is radiata pine. There are some areas where protection plantings are needed to control soil erosion on steep hill sides. The Forest Research Institute at Christchurch is testing many other exotic species and provenances, including ones that are important commercial timber trees in North America, such as lodgepole pine, ponderosa pine, Douglas fir, and western larch.

Slide 48. New Zealanders are not particularly impressed with the growth rate of these species, but it appears to me that they are growing as well here as they do in their native range. In other words, although the primary purpose of these plantings will be protection, it is quite clear that they are also producing very useable amounts of wood.

Slide 49. Biomass measurements are made to determine growth rate. This is Scotch pine being harvested, and the needles, branches, and trunk of each tree are being weighed.

Slide 50. In the short time that this stand of trees has grown, it has already made significant changes in the soil on the site. The brown A horizon has been added by the trees.

Slide 51. Many of these upland plantings have been container grown, and New Zealanders have discovered what others around the world have found, that the container is best removed before the tree is planted.

Slide 52. New Zealanders have made extensive studies which indicate that for them the styroblock is more suitable than either direct seeding or the Walter's bullet.

Slide 53. New Zealanders have also reinvented some planting tools: The brown one is a New Zealand version of the Finnish potiputki, which they claim is much more rugged, and cannot be broken even by the roughest planting crew.

REPORT ON THE NORTH AMERICAN FOREST SOILS WORKSHOP[1]

Thomas D. Landis[2]

ABSTRACT

The purpose of the workshop was the need for a technical update on forest nursery soils. Highlights of the workshop indicate, generally, that maintenance of proper soil structure is essential; a certain soil moisture should be maintained; seedling survival increases with decrease in seedbed density; etc. The entire proceedings of this workshop will not be available until 1981, however, the results of the workshop indicate that soil is an essential phase of nursery soil management and deserves continued study.

INTRODUCTION

This workshop developed as a result of the increased awareness of many nurserymen that a technical update on forest nursery soils was sorely needed. The first such workshop was held in 1965 and the state-of-the-art has undergone obvious changes in the past 15 years.

This workshop was held during the week of July 28-August 1, 1980, at the College of Environmental Science and Forestry of the State University of New York at Syracuse. It was jointly sponsored by the USDA-Forest Service, the Canadian Forestry Service, and the University.

It was appropriate that the workshop was dedicated to the memory of Dr. A.L. Leaf, who was such a vital force in the study of nursery soils. Dr. Leaf was one of the principal organizers of the workshop and his untimely death last summer threatened its existence. Only through the special efforts of Dr. Leaf's friends and coworkers could the work have gone on as planned.

The workshop attendance was truly remarkable, with nurserymen and forest scientists from across the United States and Canada. The official registration totaled 180, of which 34 were Canadians. The participants formed an ideal mixture of practicing nurserymen and leading researchers.

---

[1]Report on the North American Forest Soils Workshop, College of Environmental Science and Forestry of the State University of New York at Syracuse, New York, July 28-August 1, 1980.

[2]Westwide Nursery and Greenhouse Specialist, USDA-Forest Service, State and Private Forestry, Lakewood, Colorado.

OBJECTIVES

The objectives of the workshop included: (1) To review basic concepts of forest soils as they apply to modern nursery management; (2) to discuss soil testing procedures and their meaning to nurserymen; (3) to develop the proceedings into a reference book for the special field of nursery work.

FINDINGS

The proceedings of this conference will not be available until next year, so I would like to pass along certain highlights, which you may find of interest:

On seedling grades and quality

1. Stem diameter or caliper is the best single morphological index of seedling quality.
2. Plant moisture stress and root regeneration capacity are the best physiological measures of seedling quality.
3. Seedling outplanting survival increases with a corresponding decrease in seedbed density. Examples: pines 18-25/sq. ft.; spruce 25-30/sq. ft.

Soil physical properities

1. Soil structure is one of the most critical aspects of nursery soils because, for practical purposes, long-term changes are not possible.
2. Maintenance of proper soil structure is essential because soil pores are more important than soil solids.
3. Organic matter sources are becoming limited and the best solution may be to grow your own.

Irrigation practices

1. Soil moisture retention curves are necessary for proper irrigation scheduling.
2. As the quality of irrigation increases, differences in fertilizer responses disappear.
3. Soil moisture levels should be maintained between 0.3-1.0 bar of tension, which is more moist than traditional recommendations.

Soil Biology

1. Soil fumigants are most effective against pathogenic organisms and usually cannot be economically justified for weed control alone.
2. Newly registered herbicides have not adversely affected mycorrhizal levels in nursery soils.
3. A commercially available ectomycorrhizal inoculum is being tested and may be available if marketing problems can be overcome.

Soil fertility

1. Considerable growth loss occurs before visible symptoms of nutrient deficiencies become apparent.
2. High soil pH and salinity levels are a site selection problem, but can be overcome by proper soil and irrigation practices.

Cultural practices

1. Seed stratification periods should be lengthened beyond the Woody Plant Seed Manual recommendations, as these data were obtained under laboratory environments.
2. Management practices, such as bed density, root wrenching, and lifting date, are at least as important as irrigation or fertilization.

CONCLUSION

The attendee input gathered at the closing session was generally positive, with the major criticism being that more emphasis could have been given to interpretation of soil test results and on-the-ground problems.

Workshop proceedings will be available in early 1981, from Regional Offices of the Forest Service and from the State University of New York at Syracuse. I will be contacting all those on my mailing list as soon as they are received in my office.

It was agreed that these specialized workshops are valuable and should be held every 5-10 years. Shorter workshops could be held in conjunction with yearly nurserymen's meetings.

The State University of New York at Syracuse Soils Laboratory will continue processing nursery soil samples on a request basis. Forest Service sponsorship of soils testing will no longer be available because of funding restrictions.

We are currently working with soil scientists to develp a set of standardized techniques for nursery soil testing. Ideally, we will be able to request standard soil tests from local testing laboratories which will minimize turnaround time and encourage special treatment of local soil conditions. The most challenging problem will be to engage local soils experts to provide test data interpretation.

Soil is an essential but complicated phase of nursery soil management, but one that, I am sure you agree, deserves continued attention.

THE AMERICAN ASSOCIATION OF NURSERYMEN AND ITS GOVERNMENT NURSERY PRODUCTION COMMITTEE

Lee W. Hinds
Nurseries Manager
Lincoln-Oakes Nurseries
Bismarck and Oakes, North Dakota

The American Association of Nurserymen was organized in 1975, and has grown steadily as the national trade organization of the nursery/landscape industry. Today it serves about 3,000 member firms involved in the nursery business - wholesale growers, garden center retailers, landscape firms, mailorder nurserymen, and allied suppliers to the horticultural community.

The Association serves its members in many ways: national representation on Capitol Hill, in Federal agencies and departments; promotion of the industry and its products to the consumer through a variety of public relations and sales aids and materials, through national public service radio and television announcements, through regular press packages to the nation's top newspapers; management services in the form of valuable reference materials and regularly scheduled clinics and workshops; news, facts, opinions, forecasts distributed regularly to member firms in the form of biweekly and quarterly periodicals and at the annual convention and trade show; consulting services available to members at reduced cost in the areas of transportation, wage-hour regulations and the Occupational Safety and Health Act (OSHA); low-cost group insurance programs; a member bank card plan offering an attractively low discount rate to those firms which accept VISA and Master Charge credit cards.

The AAN has a distinguished history. The nation's first Secretary of Agriculture was a two-term president of the Association. The group is recognized as a pioneer in the highway beautification movement. It spearheaded the vital "Victory Garden" program during World War II. The AAN was responsible for instigating the existing commercial plant quarantine system.

Through its National Landscape Awards Program, the Association encourages active participation in community improvement by the business world. This program urges businesses, industrial, institutional and governmental organizations to improve the quality of their environment through landscape beautification. Over the years, the program has been chaired by prominent business and government leaders, including four First Ladies, and the presentation ceremony has occurred at the White House on five separate occasions.

The AAN encourages citizen action for environmental enhancement via its Green Survival Program which says that one person can take many small steps to protect and improve the quality of life in our land. Air, earth, water, sight, sound, energy, peace of mind, personal security - all depend in one way or another on green, growing trees and shrubs and grass and plants which are nature's gifts. The steps each citizen can take in using these gifts have come to be known by the name "Green Survival." The program, initiated in 1970, came into particular prominence in 1976 when it was recognized by the American Revolution Bicentennial Administration as an official Bicentennial activity.

Led by Robert F. Lederer, executive vice president, the staff of the AAN is also responsible for management of a group of "family" organizations. The Horticultural Research Institute is the non-profit research arm of the nursery industry; Wholesale Nursery Growers of America provide specific services for the wholesale grower; National Landscape Association serves the landscape community; Garden Centers of America counts among its members nursery retailers and garden center operators; National Association of Plant Patent Owners serves the specialized group of businesses which hold patents on plant materials.

In addition, the American Association of Nurserymen manages The Nursery Marketing Council, established in 1977 to supply the nursery industry with professional market research and analysis and the resulting advertising and public relations to increase the sale of plant materials and related products and services. NMC is funded solely by voluntary contributions. Its activities are performed for the benefit of the entire nursery industry and those businesses that serve to support and enhance nursery products.

The Wholesale Nursery Growers of America and the Horticulture Research Institute are two of the "Family Organization" that have a great deal in common with the forest and shelterbelt tree nursery production. Both are committed to less expensive ways of growing high quality plant material. It behooves us to seek cooperation at every opportunity.

The AAN has two kinds of committees, active and consultant. Active committees are those which meet periodically and develop programs within their area of responsibility or have continuing jobs to do. Consultant committees are a completely different story. Members of these committees have been selected because of their technical knowledge in a particular area of the business. They are not scheduled to meet on a regular basis, but are on tap when the chairman or staff needs counsel in a specific area.

One of the Active committees is the Government Nursery Production Committee. The primary function of this committee is to keep the government out of active participation in the nursery business, a task which requires constant vigilance.

Members of this committee include Steve McDonald of U.S. Forest Service; Robert MacLaughlin of the Soil Conservation Service; Robert Eastman of the Western Maine Forest Nursery Company; Esther Lawyer of Lawyer Nursery, Montana; Ted Korves, Plumfield Nurseries, Inc., Nebraska; and myself among others. This group does all in its power to dissuade the "government agency", at whatever level, from becoming involved in competition with private industry, whether this be Soil Districts, Municipal Entities, Experiment Stations, or State or Federal Nurseries.

All of us need to be on the alert that the private nurseryman receives every opportunity to provide the necessary plant material within his capability and at a quality acceptable for the use intended. The private sector should be assisted and encouraged at every opportunity.

For more information about the AAN contact:

American Association of Nurserymen
230 Southern Building
15th & H Streets, N.W.
Washington, D.C. 20005
(202)737-4060

EVALUATION OF HERBICIDES FOR WEED CONTROL

IN ROCKY MOUNTAIN-GREAT BASIN NURSERIES[1]

Russell A. Ryker[2]

ABSTRACT

We tested four herbicides (bifenox, DCPA, napropamide, and diphenamid) for effectiveness in reducing the hand-weeding time required for weed control in nursery seedbeds. Handweeding was reduced from 50 to 80 percent depending on herbicide and nursery. Tolerance of these herbicides by five species of pine, Engelmann and blue spruces, and Douglas-fir are summarized.

INTRODUCTION

The western nursery herbicide study is a broad-based study installed at many nurseries under a variety of conditions. The study objectives were to identify promising herbicides, develop data for product registration, and demonstrate safe and effective weed control practices for nursery seedbeds.

To conduct the study, the western United States was divided into three study areas: Pacific Coast, Rocky Mountain-Great Basin, and Great Plains. In each area a minimum of three years of work was planned. The first year was primarily a screening of 18 selected herbicides for weed control effectiveness, and tolerance by tree species. The second year, herbicides showing promise during first-year tests were tested further at different rates and time of application. Third-year tests were designed for assessing reduction in handweeding costs by each herbicide surviving the first two years of tests. For more detailed description see Ryker (1979). This report summarizes the results of third-year tests at the Rocky Mountain-Great Basin nurseries.

In addition to the planned third-year tests, at five of the nurseries we also screened oxyfluorfen (Goal 2E) for weed control and toxicity to several conifer and hardwood species. This was the first year we tested oxyfluorfen in Rocky Mountain-Great Basin nurseries.

---

[1]Paper presented at the Western Forest Nursery Council and Intermountain Nurseryman's Association combined meeting, Boise, Idaho, August 12-14, 1980.

[2]Principal Silviculturist, USDA Forest Service, Intermountain Forest and Range Experiment Station, Boise, Idaho.

METHODS

Weed Control

The third-year weed control tests were installed at six nurseries:

Nursery	Location
Coeur d'Alene	Coeur d'Alene, Idaho
Lucky Peak	Boise, Idaho
Montana State	Missoula, Montana
Mountain Home	DeBorgia, Montana
Mt. Sopris	Carbondale, Colorado
Utah State	Salt Lake City, Utah

We tested four herbicides for weed control effectiveness: bifenox (Modown 80 WP), DCPA (Dacthal W-75), napropamide (Devrinol 50 WP), and diphenamid (Enide 50 WP). The treatments are described in table 1.

The post-seeding and post-seeding plus post-germination sprays were applied to 4-by 100-foot plots with three replications. Because most nurseries did not have sufficient bed space sown to one seed source or species, different replications were usually sown to different species.

The herbicides were applied in water at a volume equivalent to 50 gallons per acre using tractor-mounted nursery spray equipment adjusted to deliver a 4.5 foot swath. The plots were irrigated to move the herbicide into the soil soon after spraying was completed.

At each nursery all plots were handweeded when needed in the most weedy plot. Crew size, total weeding time per 100-foot plot, and weeding date were recorded each time. In every case the first weeding was done just before the post-germination spray was applied. For the remainder of the season there were one or more subsequent weedings depending on the nursery.

At three nurseries (Lucky Peak, Utah, and Mt. Sopris) we counted the number of individual weeds of each species on five sample plots per 100-foot plot. The sample plots were 20 x 50 centimeters and were systematically located in the middle of the bed at 0, 20, 40, 60 and 80 feet distances within each plot. The counts were made just before the first weeding on all plots. Because only the post-seeding sprays had been applied, they reflect only the effectiveness of the post-seeding treatments.

Phytotoxicity

The 1979 study was designed primarily to determine potential savings in hand-weeding costs at each of the nurseries, but we also collected data on phytotoxicity. At most nurseries each replication was sown to a different species, so we do not have the opportunity to test the data for statistical significance of toxic effects. However, the averages are good and would indicate any serious damage from the herbicides.

The phytotoxicity data were obtained from bed-width by 1-foot sample plots located at 20, 40, 60 and 80 feet from the start of each treatment plot. We estimated a damage rating using the system proposed by Anderson (1963). The system is a scale from 0 (all seedlings dead) to 10 (no damage). We also counted live seedlings in three randomly selected rows within each sample plot, excluding the outside rows. We lifted 10 seedlings from each sample plot and determined top length, top dry weight, and root dry weight.

Table 1.--Herbicide treatments tested for weed control effectiveness during the third year, 1980

Herbicide	Formulation	Rate	Time of application
		lb a.i./A	
Untreated	--	--	--
Bifenox	Modown 80WP	3	Post-seeding[1]
Bifenox		3+3	Post-seeding plus post-germination[2]
DCPA	Dacthal W-75	10.5	Post-seeding
DCPA		10.5+10.5	Post-seeding plus post-germination
Napropamide	Devrinol 50WP	1.5	Post-seeding
Napropamide		1.5+1.5	Post-seeding plus post-germination
Diphenamid	Enide 50WP	4	Post-seeding
Diphenamid		4+4	Post-seeding plus post-germination
Diphenamid plus bifenox		4 3	Post-seeding plus post-germination

[1]Abbreviated Ps in subsequent tables.

[2]Abbreviated Ps+Pg.

RESULTS

Handweeding Time

When data from all six nurseries were averaged, the total-season handweeding time was reduced more than 75 percent by bifenox treatments, about 60 percent by DCPA and napropamide, and about 50 percent by diphenamid.

Conditions varied greatly between some of the nurseries, particularly between nurseries that fumigated the seedbed ground and those that did not fumigate. The result was that some nurseries had very few weeds, irregularly distributed, and others had many weeds. Because of these differences, we computed separate statistical analyses for each nursery.

Statistical significance of total-season weeding times at each nursery are shown in table 2. You will notice in the table that the Modown treatments at Coeur d'Alene reduced handweeding time 85 to 90 percent, but the analysis of variance shows no significance at the 95 percent level. The difference, which is obviously real, is masked by the interaction between block and treatment. Block III had about 14 times more weeds than blocks I and II. Modown kept practically all the weeds out regardless of potential. Because there were very few weeds in blocks I and II, there was little difference between treatments in those blocks.

Table 2.--Effect[1] of herbicides on total-season handweeding time in the Rocky Mountain-Great Basin Nurseries, 1979.

Herbicide	Timing	Montana	Mountain Home	Coeur d' Alene	Lucky Peak	Utah	Mt. Sopris
		Percent					
Untreated	--	100	100	100	100	100	100
Bifenox	Ps	53*	25*	15	50*	17*	7*
	Ps+Pg	23*	19*	10	36*	23*	5*
DCPA	Ps	--	45*	--	50*	32*	12*
	Ps+Pg	--	25*	--	35*	31*	12*
Napropamide	Ps	--	56*	--	63	30*	21*
	Ps+Pg	--	28*	--	92	37*	22*
Diphenamid + bifenox	Ps Pg	--	--	--	--	--	25*
Diphenamid	Ps	--	--	47	98	--	--
	Ps+Pg	--	--	46	81	--	23*

[1]Percent values shown were obtained by dividing the total-season weeding times for each treatment by the weeding time for untreated plots. The asterisk indicates that treatment mean is significantly different from the untreated mean at the 5 percent level of probability.

The weed species encountered in the sample plots at the Lucky Peak, Utah, and Mt. Sopris nurseries are listed in table 3, along with an indication of the relative degree of control by the four herbicides. Effectiveness was judged by comparing the number of seedlings per square foot on the treated and untreated plots. The data are limited and not conclusive, but may be used as an index to the relative effectiveness of the herbicides on the species encountered. For instance, bifenox was quite effective against all of these species except field bindweed, whitetop, knotweed, and some of the grasses. DCPA and napropamide were less effective against some of the other species, but effective against the grasses.

Phytotoxicity

Damage ratings, survival, height, and top and root dry weights were summarized for the five pines, two spruces, and Douglas-fir. Rather than present those rather large tables here I interpreted them in terms of the safety of the herbicide treatments for each species (table 4). All four herbicides appear safe to use on ponderosa pine, lodgepole pine, and Douglas-fir. Diphenamid, however, was the only one that did not damage Engelmann spruce. Bifenox appears safe for all the pine species tested and Douglas-fir, but not for the spruces.

Bifenox seemed to adversely affect ponderosa pine during seedling emergence at some nurseries. However, I have no measure of this and by the end of the growing season there was no significant effect on number of seedlings or seedling growth.

At the Coeur d'Alene nursery they found some of the damage[3] from dacthal reported by Pacific Coast nurseries the previous year (Callan 1979). It was limited to certain seed sources and did not occur in our plots.

[3]Personal communication with Cleve Chatterton, Assistant Nurseryman, Coeur d'Alene Nursery.

Table 3.--Relative effectiveness[1] of the four herbicides on the major weed species.

Species	Bifenox	DCPA	Napropamide	Diphenamid
Clover	+	-	-	-
Common mallow	+	-	-	*
Dandelion	+	+	+	+
Field bindweed	-	-	-	*
Filaree	+	+	-	-
Grass spp.	-	+	+	+
Jerusalem oak	+	+	+	-
Knotweed	-	-	-	-
Kochia	+	+	-	*
Lambsquarter	+	+	-	-
Mint spp.	+	+	-	-
Nightshade	+	+	-	*
Prickly lettuce	+	+	+	*
Prostrate pigweed	+	+	-	-
Purslane	+	+	+	+
Redroot pigweed	+	+	+	+
Russian thistle	+	-	-	*
Shepherdspurse	+	-	-	+
Sunflower	+	+	-	*
Tansy mustard	+	-	-	*
Thistle spp.	+	+	+	*
Whitetop	-	-	+	*

[1] A "+" indicates the herbicide was effective against that species. A "-" indicates the herbicide was less effective. An * indicates the herbicide was not tested at the nurseries where this species appeared in the plot measurements.

Table 4.--Relative safety[1] of the four herbicides tested in 1979 on eight conifer species.

Species	Bifenox Ps	Bifenox Ps+Pg	DCPA Ps	DCPA Ps+Pg	Napropamide Ps	Napropamide Ps+Pg	Diphenamid Ps	Diphenamid Ps+Pg
ponderosa pine	X	X	X	X	X	X	X	X
lodgepole pine	X	X	X	X	X	X	X	X
Austrian pine	X	X	X	X	No	No	-	-
mugo pine	X	X	?	?	?	?	-	-
Scotch pine	X	X	X	X	?	?	-	-
Douglas-fir	X	X	X	X	X	X	X	X
Engelmann spruce	No	No	No	No	?	?	X	X
blue spruce	?	?	No	No	No	No	-	-

[1] X--indicates those treatments that have been consistently safe to use in our study plots. No -- indicates treatments that have been too damaging. ? -- results uncertain or varied between nurseries. The dashed line indicates treatments not tested against that species.

OXYFLUORFEN PHYTOTOXICITY

In addition to the planned third-year study on the large plots, we installed some phytotoxicity tests of oxyfluorfen at five nurseries (Coeur d'Alene, Idaho, Lucky Peak, Utah, and Mt. Sopris). We tested it on four species of conifers and three species of hardwoods.

No weed control data were collected but observations indicated almost complete weed control until about midsummer by the post-seeding treatment. Total season weed control appeared to be as good or better than with bifenox. If safe to use, this should be a very important herbicide for nursery weed control.

Number of seedlings and height growth of Douglas-fir and ponderosa pine were not significantly affected by oxyfluorfen. Lodgepole pine was not damaged at Lucky Peak nursery, but at Mt. Sopris the number of seedlings was reduced about 60 percent and height growth reduced about 25 percent. The reason for the difference between nurseries is not known. The effects on Engelmann spruce were highly variable within each nursery. The 2X rate was particularly damaging. All three hardwood species (Russian olive, willow, and squawbush) benefitted from the reduction in competition on treated plots.

Oxyfluorfen (Goal 2E) is now registered (EPA Reg. No. 707-145-AA) for use in conifer seedbeds. Lodgepole pine is included in the species list as is Colorado blue spruce. Our results in last year's tests indicate further phytotoxicity tests should be conducted at each nursery contemplating using this herbicide. This is particularly true for nurseries growing lodgepole pine and the spruces. The effectiveness of this herbicide for controlling weeds fully justifies further testing.

PUBLICATIONS CITED

Anderson, H. W.
1963. A system for evaluating effective weed control in forest nurseries. Tree Planters' Notes 61:19-23.

Callan, Nancy W.
1979. Dacthal injury on Douglas-fir and true firs at the Medford Forest Nursery. In Proceedings Intermountain Nurseryman's Association meeting August 13-16, 1979, Aspen, Colorado. p. 23-24.

Ryker, Russell A.
1979. Western nursery herbicide study--1979 update. In Proceedings Intermountain Nurseryman's Association meeting August 13-16, 1979, Aspen, Colorado. p. 16-22.

THE WESTERN FOREST TREE SEED COUNCIL[1/]

D.G.W. Edwards [2/]

The Western Forest Tree Seed Council is a member council of the Western Reforestation Coordinating Committee of the Western Forestry and Conservation Association. It is organized to solve problems concerning tree seeds among organizations and individuals in the eleven Western States and British Columbia, and represents western forestry interests in matters of tree seeds. The Council Charter, adopted in 1965, allows that any person actively engaged in tree seed matters shall be a member in good standing with full privileges. Members meet periodically to discuss problems of common interest, to exchange scientific information and to undertake cooperative projects that will enhance reforestation practices.

The Council came into being as the Northwest Forest Tree Seed Committee in 1953 in Corvallis, Oregon. A name change to the Western Forest Tree Seed Council reflected its affiliation with the Western Forestry and Conservation Association and its geographic scope encompassing the western United States and Canada. While its objectives have broadened over the past 27 years, the Council continues to actively encourage, promote and participate in seed studies and the reporting of seed research. Space for an annual Seed Council report is provided in the proceedings of the Western Reforestation Coordinating Committee. The Committee and the parent Association serve as forums in which the Council can air important seed concerns before larger audiences. The Association has adopted several resolutions from the Seed Council and has also provided much needed assistance in reproducing and distributing several Council publications.

The Council executive comprises four officers elected every second year. Meetings are held at least once a year, more frequently if the need arises, and written minutes are circulated. As with many other organizations, the interest in and activities of the Western Forest Tree Seed Council have been difficult to sustain at certain times. During the early and mid-1960s, considerable activity centered around amendments to the Federal Seed Act, the development of seed zone maps and a seed certifying agency, to mention only a few. In 1975-76, a proposal surfaced to place the Council in an inactive status, since no critical seed issues were recognized at that time. However, the Council has rebounded vigorously in the last 4 or 5 years, due to the leadership of Ed Hardin of the Oregon State Seed Laboratory.

A series of committees concerned with seed standards, certification, legislation, seed zones, research, referee testing and other matters have carried forward most of the Council's activities. The early achievements have been

---

[1/] Paper presented at Joint Meeting of Intermountain Nurseryman's Association and Western Forest Nursery Council, Boise, Idaho, Aug. 1980.

[2/] Chairman, Western Forestry Tree Seed Council. Mailing address: Canadian Forestry Service, Pacific Forest Research Centre, Victoria, British Columbia.

documented by Stein (1974)[1], so only a brief synopsis is necessary here.

i) The 1966 Seed Zone Map for Oregon and Washington. Revised in 1975, allowing zones to mesh with those in adjacent states and British Columbia.

ii) Establishment of the Northwest Forest Tree Seed Certifiers Association, also in 1966.

iii) In the late 1960s, the development of a Model State Seed Law for forest tree seeds.

iv) Publication of a booklet on tree seed testing techniques, first issued in 1959. The Council's testing methods for tree seeds were adopted by the Association of Official Seed Analysts in 1965, and an updated booklet on tree seed sampling and testing was published in 1966.

v) Secured funds for a study on germination in Abies species, the results of which were published in two reports by the Oregon State Seed Testing Laboratory.

vi) Continued to press for additional research on western forest tree seeds, culminating in a proposed seed research program aimed primarily at (a) improving seed processing, (b) better seed testing, and (c) improved seed use. The proposed program was to be conducted at a federally funded laboratory in Corvallis.

Since 1976, the Council has persisted in emphasizing seed research needs. The Seed Research Committee met with the Director and Assistant Director (South) of the Pacific Northwest Forest and Range Experiment Station to explore the development of the much needed cone and seed research program. Although space and equipment have been allocated in the Corvallis station, completed in 1977, no work has been initiated.

Despite the compilation of a list of tree seed research requirements that identified more than 20 problem areas, such work retains low priority in the PNW Station's plans, since funding is still a major stumbling block. As something of a palliative, the Council has encouraged and promoted active participation in its meetings of seed researchers employed by private industry, university and other government agencies. In the last 3 years, a considerable amount of tree seed research has been reported to the Council by representatives from Weyerhaeuser Company, Washington State and Oregon State Universities, the British Columbia Ministry of Forests and the Canadian Forestry Service, and others. This work is the result of individual programs at each Centre and remains uncoordinated. Many of the problems identified by seed workers in the Pacific Northwest remain unresolved and the Western Forest Tree Seed Council must redouble its efforts of pressuring for funds if new seed programs are to be undertaken.

Other activities in recent years include:

vii) Referee testing of Douglas-fir and Abies species. Two 2-day workshops were

---

[1] Stein, W.I. 1974. Activities of the Western Forest Tree Seed Council. Proc. Western For. Nurs. Council, Portland : 3-7.

also promoted by the Council and held in the facilities of the Oregon State Seed Testing Laboratory. Each workshop attracted some 30 participants who studied purity and germination testing, and the so-called quick tests (tetrazolium, excised embryo, hydrogen peroxide and x-ray). Emphasis was on uniformity of testing through the use of procedures described in the AOSA Rules.

viii) A long-term seed storage project at the National Seed Storage Laboratory, Fort Collins, Colorado, that now includes several tree species.

ix) Compilation of a list of tree seed research requirements. The list, identifying 23 problem areas, was widely distributed.

x) A half-day symposium on Seed Vigor was held during the 1979 meeting. Participants had the components of seed vigor and the testing of seed vigor explained by staff members of Oregon State University.

xi) The last three annual meetings have seen detailed accounts of research on revegetation of disturbed lands; true fir seed maturity, cone and seed insect control, cone collection and after-ripening, grading and sorting; air drying of stratified seeds of ponderosa pine and Douglas-fir to improve germination; quick tests to replace standard germination tests, and drying and storing stratified true fir seeds.

The Council is working toward revising and re-issuing the booklet on "Sampling and Service Testing Western Conifer Seeds" and is considering the preparation of a publication on quick tests. Other seed testing workshops have also been proposed.

Peripheral supporting actions continue, as ongoing events and as new developments, but the Council's major concern is the lack of implementation of its seed research program. As nurserymen, you are as vitally concerned with tree seeds as anyone, and your support of the Western Forest Tree Seed Council is highly valued. On behalf of the Council, I invite your participation in all our activities, and especially welcome your support on problems of mutual concern.

AN INTRODUCTION TO THE WESTFIR TRANSPLANT NURSERY [1/]

Rodney F. Matye [2/]

Approximately 40 miles southeast of Eugene, Oregon, along the Willamette Pass Highway, lies the small community of Westfir. Here, at the foothills of the Cascade Range, is where the Westfir Transplant Nursery is situated.

The Nursery was established in 1960 by the Willamette National Forest to: "provide a large vigorous seedling which could be lifted and planted to the field in a very short time". The Nursery lies on alluvial terraces of the Middle Fork of the Willamette River at an elevation of 1,020 feet. The annual precipitation rate is 42 inches of rainfall and the mean average temperature is 53 degrees Fahrenheit.

In proposing the establishment of Westfir, the Forest contemplated the production of transplant stock solely for those sites most difficult to reforest. Furthermore, the Forest recommended the transplant operation be discontinued when stock of equal quality but lower cost became available.

We have come a long way since those Forest recommendations were made. Outplanting of Westfir stock began in the fall of 1960. In December of 1961, the nursery was enlarged to 6 acres, with a projected capacity of 1.4 million seedlings. Trees being lifted, in those days, had to transported to the Flat Creek Work Center for processing, a distance of 10 miles. The equipment for nursery work came from surplus property lists, except for the tractors, those were rented from local farmers.

The efficient and economical operation of the nursery required additional bed space, equipment storage facilities, the acquisition of additional equipment, the construction of a processing room and a cold storage facility. The process of getting approval and budgeting for these improvements came over a span of six years.

Since 1976, additional improvements have been made at the Nursery. We identified soil problems arising from extended use of Simazine and Atrazine as well as some poor cultural practices. Through close cooperation with the Forest soil scientist and other personnel, a soil management plan was developed and activated.

In 1978, a new office and an additional tree storage facility were under construction. These are completed now and provide a pleasant atmosphere for the 50 employees the facility employs during its operating season.

Today we have 17 acres available for transplant seedlings. We try to put 4-5 acres a year into a cover crop of annual rye grass.

1/ Paper presented at Joint Meeting of Western Forest Nursery Council and the Intermountain Nurseryman's Association, Boise, Idaho, August 12-14, 1980.
2/ Nurserymanager, Westfir Transplant Nursery, U.S.D.A. Forest Service, Oakridge, Oregon 97492.

A serious drainage problem, which caused mortality and chlorotic trees, was reduced and in some cases eliminated by installing 7 miles of perforated drainage pipe. The installation of this pipe, with laser equipment, to maintain depth and slope specifications, was a real learning experience in itself.

Irrigation efficiency was increased with the installation of a new pump and mainline assembly. Our water is pumped directly from the river by a submersible Jacuzzi 7½ horsepower pump. A 6 inch mainline feeds the 2 inch laterals where 55 psi head pressure is maintained for uniform coverage.

As is the case at most nurseries, Westfir has a weed problem. An aggressive weed control program which includes fumigation, as well as the utilization of herbicides and hand weeders, helps keep the situation manageable.

The Nursery utilizes two International tractors for heavy cultivation work and a small International for light cultivation.

A Mann-Fleming tree lifter, with spare shaft, is used for lifting. Our transplanting is accomplished by using a New-Holland Model #500 six row transplanter. We have found this model easy to adjust and it can be operated at a fairly good rate of speed.

The Nursery last year provided services to four National Forests and the Bureau of Land Management. We produced 1.9 million transplants at a cost of $190/M.

The Nursery has generally been transplanting bare-root 2-0 seedlings grown from the Wind River, Medford and Humbolt Nurseries. We have noticed an increased request for transplanting 1-0 bare-root seedlings as well as some containerized stock.

This year as in the past few years we regretfully turned away potential customers because we had already filled all available bed space. Even though - there is talk of a new nursery in the Willamette Valley, I believe Westfir, as well as other transplant nurseries, can expect a very productive future.

ECTOMYCORRHIZAE: PRESENT STATUS AND PRACTICAL APPLICATION IN FOREST TREE NURSERIES AND FIELD PLANTINGS[1]

Charles E. Cordell and Donald H. Marx[2]

ABSTRACT

Increased growth and quality have occurred in test lots of seedlings at bareroot and containerized seedling nurseries that participated in trials of practical applications of selected ectomycorrhizal fungi. Increased tree survival and growth also occurred in related field plantings on a wide variety of conifer species and planting sites. Several alternative methods are presented concerning the practical inocualtion of nursery seedbeds with ectomycorrhizal fungus inoculum.

Additional key words: *Pisolithus tinctorius*, ectomycorrhizal inoculum, conifer host species, seedling growth and quality, tree survival and growth, bareroot nurseries, container nurseries, ectomycorrhizal inoculation techniques.

INTRODUCTION

During the past several years, researchers at the Institute for Mycorrhizal Research and Development (IMRD), Athens, Ga., and pest management specialists, Atlanta, Ga., both with the USDA Forest Service, have been conducting extensive mycorrhizal research and field application studies with several forestry agencies. This work has centered around one ectomycorrhizal fungus, *Pisolithus tinctorius* (*P.t.*), and its practical application to forest tree nurseries and field forestation.

Since 1977, a national evaluation has been in progress to test the effectiveness of different formulations of *P.t.* inoculum produced by Abbott Laboratories, Chicago, Ill., and the IMRD on selected conifer seedling species. A progress report on this evaluation was presented at the Western and Intermountain Nurseryman's Conference, Snowmass, Colo., August, 1979 (Cordell and Marx, 1979).

---

[1] Paper presented by senior author at the Western and Intermountain Nurserymen's Conference, Boise, Idaho, August 11-15, 1980.

[2] National Coordinator, National Mycorrhizae Nursery Evaluation, Forest Pest Mgt., Southeastern Area, USDA Forest Service, Asheville, N.C., and Direstor, Institute for Mycorrhizal Research and Development, Southeastern Forest Experiment Station, USDA Forest Service, Athens, Ga., respectively.

During the past 3 years, over 80 bareroot nursery tests have been conducted in some 38 states. Eighteen companion container nursery seedling evaluations have also been conducted in nine states (including Hawaii) and Canada. The objective of these evaluations was to compare the effectiveness of P.t. inocula produced by the IMRD and Abbott Laboratories for P.t. ectomycorrhizal formation, seedling growth and quality in the nursery, and tree survival and growth in subsequent field outplantings. Results obtained from these field studies continue to be encouraging and suggest that P.t. may have practical application for a variety of conifer and some hardwood seedling species produced in bareroot and container nurseries.

PRESENT STATUS OF P. TINCTORIUS ECTOMYCORRHIZIE

Bareroot and Container Nurseries

Research and nursery field evaluation results continue to demonstrate that P.t. can be successfully, artificially inoculated into prefumigated nursery seedbeds(fig. 1) (Marx, et. al., 1976, Marx and Artman, 1978) and container mixes (Ruehle and Marx, 1977). Successful seedbed inoculations have been obtained in a variety of nurseries with various conifer species and some hardwoods (oaks). Positive bareroot nursery seedling benefits involving significant increases and decreases in seedling fresh weight and cull percentages respectively, have been observed in several nurseries, (Cordell and Marx, 1979). Thus far, the P.t. inoculum produced by the IMRD has been more effective and consistent than the Abbott P.t. inoculum in the formation of P.t. ectomycorrhizae and effect on seedling growth and quality. Some Abbott P.t. inoculum batches, however, have been highly effective. Research in 1980 by the IMRD and Abbott Laboratories is aimed at rectifying these formulation problems.

Figure 1.--*Pisolithus tinctorius*

Results obtained from the 1978 container seedling studies with both the IMRD and Abbott P.t. inocula were highly encouraging (Cordell and Marx, 1980). The IMRD P.t. inoculum produced an average of 40 percent P.t.ectomycorrhizae on seedling feeder roots. The Abbott P.t.inoculum produced an average of 20 percent P.t. ectomycorrhizae and both inoculum sources produced some P.t. ectomycorrhizae on 100 percent of the seedlings inoculated. Note that these positive results were obtained on 12 conifer and one hardwood (burr oak) species in seven States (Maine to Georgia to Oregon) along with Ontario, Canada.

Field Plantings

A number of outplanting tests were made on a variety of forestation sites--routine, coal spoil, kaolin wastes, etc. -- in scattered locations in the United States before the national IMRD-Abbott inoculum evaluation (Berry and Marx, 1978; Cordell and Marx, 1977; Marx, et al., 1977). Significant increases in tree survival and growth (25+%) have been obtained on some sites after 6 years in the field. Field forestation benefits have been consistently higher on the poorer quality planting sites. Initial outplantings with the Abbott P.t. were established during the Spring of 1979. To date, over 20 outplantings have been established involving a variety of conifer species and planting sites across the United States. The outplantings are scheduled for a 10-year duration, with annual tree measurements and progress reports.

P.t. Inoculum Availability

Abbott Laboratories developed techniques and procedures for the commercial production of P.t. mycelium-vermiculite-peat inoculum. During the past 3 years, this firm and IMRD have been conducting extensive cooperative research and field evaluation studies of the commercial production of P.t. fermentor inoculum for practical application in forest tree nurseries.

The future commercial production of P.t. inoculum by Abbott Laboratories, or an alternate producer, will depend, primarily, on the consumer demand (forest tree nurseries) and the prevailing economy. Presently, the indicated nursery demand for P.t. inoculum and prevailing economical conditions are not highly favorable for the commercial production of this product. Any commercial P.t. production by Abbott Laboratories in the next few years will most likely be based on special agreements and custom P.t. inoculum orders between various nurseries and the company.

Several alternative P.t. inoculum producers, types and practical nursery inoculation techniques are being investigated by the USDA Forest Service. The most promising inoculum types and seedbed inoculation techniques are described in the following section.

PRACTICAL APPLICATION OF P. TINCTORIUS IN BAREROOT AND CONTAINER NURSERIES

The most practical and effective means of using P.t. is by inoculating either bareroot nursery seedbeds or containers before seeding. Best results have also been obtained following effective methyl bromide soil fumigation of the nursery seedbeds. Seedling container mixes can be easily and effectively treated with the inoculum before seeding (Ruehle and Marx, 1977).

The following possible alternatives are available for consideration with P.t. inoculations in bareroot nurseries:

1. Commercial inoculum broadcast on seedbed surface with fertilizer spreader equipment and rototilled in with a bed shaper before seeding. This method is simple and does not require special equipment. However, it requires a larger, much more expensive volume of P.t. inoculum

2. P.t. spores mixed with hydromulch and applied to nursery seedbeds immediately after seeding. This method has primary advangages similar to 1, above, other than the need for a hydromulcher. However, there are several disadvantages to this inoculation method. First, a large volume of P.t. spores is required. Second, the spore germination lag time gives a competitive advantage to other soil fungi. Results to date have shown the P.t. spore inoculum to be less effective than laboratory-grown P.t. inoculum (mycelium without spores) in nursery seedbeds. However, results obtained from a P.t. spore hydromulch inoculation study in Oklahoma were very effective (Marx, et al., 1979).

3. P.t. spore encapsulated seed treatments. Although still under study, preliminary results have been very promising. The advantages and disadvantages of this method are similar to other P.t. spore inoculation methods. In cooperation with the IMRD, the International Tree Seed Company, Birmingham, Ala., is developing plans and techniques for the production of P.t. spore-encapsulated seed for a variety of conifers.

4. Commercial inoculum applied in nursery seedbed drill rows with an ectomycorrhizal inoculum applicator-tree seeder. During 1979, a nursery seed planter was modified by the USDA Forest Service for the simultaneous application of P.t. inoculum and seedbed sowing in nursery seedbeds (fig. 2). The ectomycorrhizal inoculum applicator-tree seeder is being tested in four southern nurseries during 1980. If effective in promoting P.t. development on seedling feeder roots, such a machine should be highly useful in forest tree nurseries. A major advantage of this seedbed row-drilled technique would be a much lower volume for P.t. inoculum (67 percent less than seedbed broadcast method) as well as substantial savings in time, labor, and other costs. The additional machine requirement is a primary disadvantage. However, most existing nursery seeders could be modified, at relatively minimal cost, to apply the inoculum.

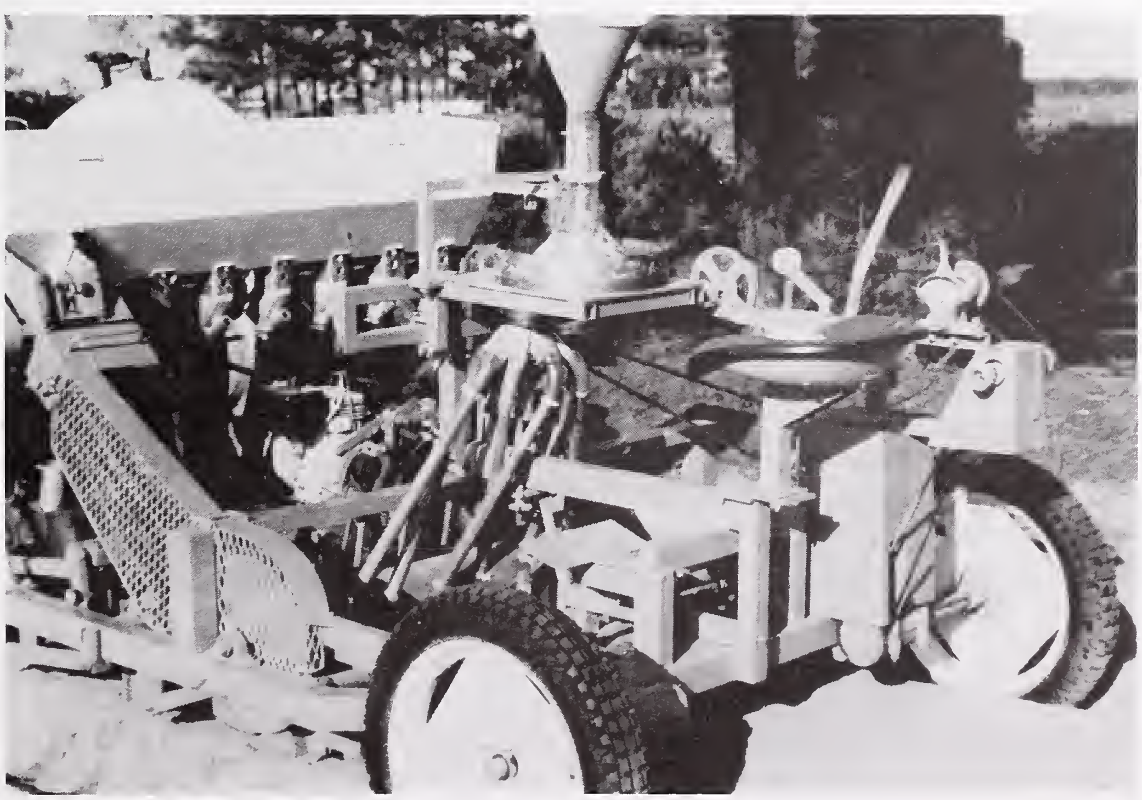


Figure 2.--Inoculum applicator-tree seeder

SUMMARY AND CONCLUSIONS

1. Certain ectomycorrhizal fungi, such as P.t., can be successfully artificially inoculated into container seedling mixes and bareroot seedbeds with both mycelium and spore inoculum.

2. The P.t. mycelium inoculum, however, has been superior to the spore inoculum.

3. P.t. has a very broad seedling host and geographic range across the United States and around the world. Other ectomycorrhizal fungi may act similarly.

4. Positive seedbed and container inoculation benefits involving seedling growth and quality in the nursery along with increased tree survival and growth in field plantings have been repeatedly demonstrated.

5. Several potential practical P.t. inoculum application techniques, using either mycelium or spore inoculum, in container and bareroot nurseries are available for consideration by the nurseryman.

6. A variety of additional ectomycorrhizal fungi (i.e., *Thelephora*, *terrestris*, *Rhizopogon*, *Laccaria*, etc, may be more effective and practical for nursery application than P.t. in specific locations in the United States (i.e., Pacific Northwest). However, the same application techniques previously described can be modified for use with other ectomycorrhizal fungi.

7. The application of ectomycorrhizae to nursery seedling production is another "tool" for use in the quest for increased quality seedling production. Therefore, we challenge all nurserymen to become fully aware of the potential benefits and practical application of ectomycorrhizae in quality seedling production. This will enable the nurseryman to properly evaluate this "tool" for nursery use the same as for other high-quality products.

LITERATURE CITED

Berry, C.R. and D.H. Marx.
1978. Effects of *Pisolithus tinctorius* ectomycorrhizae on growth of loblolly and Virginia Pines in the Tennessee Copper Basin. U.S.D.A., Forest Service Research Note SE-264. 6 pp.

Cordell, Charles E. and Donald H. Marx.
1979. Results of 1978 *Pisolithus tinctorius* ectomycorrhizae national evaluation in 33 bareroot nurseries and 18 container seedling studies in the U.S. Western and Intermountain Nurserymen's Conference, Proceedings. Snowmass, Colorado. August, 1979. p. 28-31.

Cordell, Charles E. and Donald H. Marx.
1977. Mycorrhizae + tree seedlings = increased southern timber production. Southern Lumberman. 234(2907): 11-12.

Marx, D.H., W.C. Bryan, and C.E. Cordell.
1977. Survival and growth of pine seedlings with *Pisolithus* ectomycorrhizae after 2 years on reforestation sites in N.C. and Fla. For. Sci. 23: 363-373.

Marx, D.H. and J.D. Artman.
1978. Growth and ectomycorrhizal development of loblolly pine seedlings in nursery soil infested with *Pisolithus tinctorius* and *Thelephore terrestris* in Virginia. U.S.D.A., Forest Service Research Note SE-256. 4 pp.

Marx, Donald H., John G. Mexal, and William G. Morris.
1979. Inoculation of nursery seedbeds with Pisolithus tinctorius spores mixed with hydromulch increases ectomycorrhizae and growth of loblolly pines. Southern Journal of Applied Forestry. 3(4): 175-178.

Ruehle, J.L. and D.H. Marx.
1979. Developing ectomycorrhizae on containerized pine seedlings. U.S.D.A., Forest Service Research Note SE-242. 8 pp.

ROOT MORPHOLOGY CONTROL IN FOREST TREE SEEDLING CONTAINERS[1]

S. E. McDonald, R. W. Tinus, and C.P.P. Reid[2]

ABSTRACT

Controlling seedling root morphogenesis in containers with chemicals can result in seedlings which rapidly establish natural root systems following outplanting. Copper and synthetic auxin compounds placed on the interior walls of containers reversibly stop root growth at the container wall. This has resulted in an adventitious proliferation of root tips up and down the root plug cylinder. These tips grow radially outward from the plug when the trees are planted so that many growing points penetrate the soil at various soil depths. As a result, trees should become rapidly established, be better anchored, and grow faster.

INTRODUCTION

Tree seedlings grown in forest tree containers frequently become stunted or die several years following outplanting (Hellum 1978). Sometimes they become prone to windthrow (Chavasse 1978). These and other problems with tree growth following outplanting often occur not only with container seedlings, but also with bare-root trees (Van Eerden and Kinghorn 1978). Root system deformities are thought to be the prime cause. These deformities seem to fall into two categories for containerized stock:

1. Root tips are concentrated in the bottom of the planting hole and grow into the soil only at the bottom of the hole following outplanting.
2. Roots penetrate the soil only to a limited extent following outplanting, and form an increasingly compacted mass in the original root plug area.

Is there a way to grow trees at the nursery to prevent these field problems?

---

1. Paper presented at the Joint Meeting of the Intermountain Nurserymen's Association and Western Forest Nursery Council, Boise, Idaho, August 12-14, 1980.

2. Respectively, Tree Improvement Specialist, Cooperative Forestry Staff, State and Private Forestry, USDA-Forest Service, Washington, D.C.

Project Leader, Rocky Mountain Forest and Range Experiment Station, USDA-Forest Service, Bottineau, North Dakota.

Professor of Forest Tree Physiology, Department of Forest and Wood Sciences, College of Forestry and Natural Resources, Colorado State University, Fort Collins, Colorado.

In 1978, Dr. A. N. Burdett (1978) of the BCFS Research Division, Victoria, Canada, reported that copper carbonate in acrylic latex paint applied to container walls would reversibly stop root growth at the wall. This was done by mixing a small amount of copper carbonate (30 to 100 g/l) with acrylic latex paint and painting the inside of the container with the mixture before growing the trees in it. When their tips reached the wall of the containers, many of the lateral roots of the seedlings stopped growing instead of turning and continuing to grow down the walls to the root egress hole. The laterals that stopped often developed a series of adventitious roots. These roots also stopped growth at wall contact. The result was a series of root tips _at_ the container wall. Upon removal from the container, these root tips resumed growth outward from the sides of the root "plug." This lateral root growth promised better lateral anchorage and access to water and nutrients and suggested such root morphogenesis control could be a feasible operational procedure. Accordingly, a cooperative research effort between the U.S. Forest Service and Colorado State University was started to validate Burdett's work and extend knowledge about the technique.

PROJECT DESCRIPTION

The goal was to control seedling root development in nursery containers so root growth following outplanting would take place rapidly and in a more or less natural pattern. Factors to be manipulated were (1) root density in the container, (2) mechanical configuration of the container, and (3) chemical applications to the interior walls of the containers. The first stage, being reported on here, sought to (1) corroborate Burdett's work, (2) evaluate the possibility of using other root growth inhibitors the same way, and (3) to check the effects of these inhibitors over a range of concentrations.

MATERIALS AND METHODS

Spencer-Lemaire 30 cu. in. bookplanters[R] were used in the rate spectrum test. When laid out flat the interior of this type of container is easily painted with a brush. Three chemicals were mixed with the paint:

1. copper carbonate ($CuCO_3$).
2. indole-3-butyric acid (IBA), a synthetic auxin which has been shown to inhibit root growth in many plants at concentrations in excess of 10^{-7} to 10^{-13}M (Salisbury and Ross 1978).
3. trifluralin herbicide (Eli Lilly's Treflan EC) which inhibits root growth (Nussbaum 1969).

These chemicals were used in the following treatments:

Additive	White Paint[1]	Black Paint[1]
None	No paint	No paint
None	Paint only	Paint only
Copper	100 g/l	-[2]
Copper	10 g/l	-
Copper	3 g/l	-
Copper	1 g/l	-
IBA	50.0 g/l	50.0 g/l
	5.0 g/l	5.0 g/l
	0.5 g/l[3]	0.5 g/l
	0.05 g/l	0.05 g/l
	0.005 g/l	0.005 g/l
	0.0005 g/l	0.0005 g/l
Treflan	70.88 g/l[4]	70.88 g/l
Treflan	14.18 g/l	14.18 g/l
Treflan	2.84 g/l	2.84 g/l
Treflan	0.56 g/l	0.56 g/l

1/ Because IBA and Treflan degrade in light and paint pigment differences may affect results, two colors were employed.

2/ Only a white paint treatment was used, since $CuCO_3$ is not affected by light.

3/ Approximately 10^{-2}M.

4/ The recommended herbicide dose for silt soils (grams per liter of spray solution) would equal about .12 cc per liter of solution.

The solutions in the tabulation were applied to the inside of the containers, the paint allowed to dry, and the containers filled with growing medium. Ponderosa pine (Pinus ponderosa LAWS.) seeds were placed in the cavities and covered with a thin layer of perlite. There were three replications of four cavities (three books) for each treatment. The replications were randomly placed in wire container rocks and put into a greenhouse for germination and growth. Seeding and culture of the seedlings followed directions in Tinus and McDonald (1979).

When the seedlings were judged to be of plantable size and had enough root development to provide a cohesive root plug, the trees were removed from the containers. Half were transplanted to a greenhouse bench filled with moist vermiculite for continued growth. The growing medium was gently removed from the roots of the other half. Shoot height, number of needles, needle length, dry weight shoot, dry weight root, the number of roots deflected downward at the wall, and the number of roots reaching the egress hole were measured or counted.

RESULTS

The principle results of this work were:

1. Treflan had a deleterious effect on seedlings at all concentrations. It was dropped.
2. There was little difference between trees grown in black versus white containers.
3. At 100 g/l, copper carbonate was effective in limiting root downturn at the wall as shown below:

$CuCO_3$ Concentration (g/l)	Root Deflected	Roots at Egress Hole
0	12.2	21.5
1	7.5	18.5
3	9.0	20.3
10	9.7	21.5
100	3.7	13.2

In addition, the copper carbonate appeared to stimulate growth as the concentration increased:

$CuCO_3$ Concentration (g/l)	Height(cm)	Dry Weight Shoot (g)	Dry Weight Root (g)
0	44.2	0.48	0.35
1	48.7	0.60	0.39
3	54.8	0.92	0.54
10	54.8	0.81	0.48
100	65.2	1.00	0.61

4. At 50 g/l the IBA effect was similar to $CuCO_3$, but not quite so strong. At lower concentrations there was some growth stimulation.
5. After removal of the seedlings from the containers, the IBA and $CuCO_3$ coatings were still in very good condition and could probably have been used several times more.

The other half of the trees, previously removed from their containers and planted in moist vermiculite, were grown for about five weeks (11/29/79-1/9/80). They were then removed from the growing medium and the total length of each new side or bottom root was measured. The length of side roots as a percentage of total root length was calculated as shown below:

$CuCO_3$ Treatment (g/l)	Side Roots as Percent of Total Roots
0	7.8
1	4.7
3	12.1
10	12.0
100	27.1

IBA Treatment (g/l)	Side Roots as Percent of Total Roots
0	9.4
0.0005	13.3
0.005	5.2
0.05	12.9
0.5	11.7
5.0	18.9
50.0	34.3

DISCUSSION

The prime variable not addressed in the work reported here is root density in the container, a function of growing time. Root crowding in the container may strongly affect how roots develop after trees are outplanted. Work currently underway addresses this question by comparing $CuCO_3$ and IBA wall coatings and lateral root egress holes with various degrees of root development of ponderosa pine. We hope to determine a container treatment - degree of root development combination that will allow seedlings to develop a natural, or better than natural, root system. Other work in progress includes:

1. Finding the actual concentration of copper and IBA ions which cause the root growth inhibition at the container wall.
2. Developing methods for quickly screening a variety of other ions and ion concentrations for temporary root inhibition. The object is to find cheaper, possibly more effective, chemicals to use.
3. Perhaps there will be higher mycorrhizal infection rates in chemically treated seedlings. This should follow, since there are more root tip growing points for mycorrhizal fungi to inhabit. Tests are being conducted with Pisolithus tinctorius and Suillus granulatus fungi (in cooperation with S. Grossnickle, College of Forestry, Colorado State University).

SUMMARY

There is potential for development of container seedlings that will have root tips, pointing outward and ready to grow, all over the surface of the root plug. Upon planting, the rapid extension of these roots into surrounding soil could very quickly produce a root system as good as, or better than the root system of a tree seeded in place. Roots would grow into the upper soil layers for good lateral force resistance and absorbtion of nutrients as well as downward. Such trees would be healthier, become fully established faster, and be less prone to windthrow in later life. Much more research needs to be done, but initial results are very encouraging.

PUBLICATIONS CITED

Burdett, A. N.
1978. Control of root morphogenesis for improved mechanical stability in container-grown lodgepole pine. Can. J. For. Res. 8:483-486.

Chavasse, C.G.R.
1978. The root form and stability of planted trees with special reference to nursery and establishment practice. In Proc. of the Root Form of Planted Trees Symposium, E. Van Eerden and J. M. Kinghorn Eds., Victoria, B.C., Canada, May 16-19, 1978. British Columbia Min. For./CFS Joint Rpt. No. 8. pp. 54-64.

Hellum, A. K.
1978. The growth of planted spruce in Alberta. In Proc. of the Root Form of Planted Trees Symposium, E. Van Eerden and J. M. Kinghorn Eds., Victoria, B.C., Canada, May 16-19, 1978. British Columbia Min. For./CFS Joint Rpt. No. 8. pp. 191-196.

Nussbaum, J. J.
1969. Chemical pinching of roots of container plants. Calif. Agriculture 23 (10): 16-18.

Salisbury, F. S., and C. W. Ross.
Plant Physiology. Second Ed., Wadworth Publ. Co., Belmont, Calif., pp. 404.

Tinus, R. W. and S. E. McDonald.
1979. How to grow forest tree seedlings in containers. USDA For. Serv. Gen Tech. Rpt. RM-60. pp. 256.

Van Eerden, E., and J. M. Kinghorn, Eds.
1978. Proc. of the Root Form of Planted Trees Symposium. Victoria, B.C., Canada, May 16-19, 1978. British Columbia Min. For./CFS Joint Rpt. No. 8 pp. 357.

QUALITY CONE COLLECTION[1/]

Alfred Borchert[2/]

ABSTRACT

Good forest management depends on the fast reforestation of logged areas with the right species of seedlings that are vigorous and healthy and from the proper area of location. To produce vigorous healthy seed and seedlings, proper quality cone collection and handling is a must. To accomplish quality cone collection, a lot of technical and biological know-how, as well as "Common Sense" must be exercised. To accomplish the job, proper planning and good existing seed bank records are needed.

INTRODUCTION

This presentation will focus on the collection of cones from Douglas-fir, since we have had very little experience collecting cones from other species. However, most basic principles and common sense will apply to any other species. The harvest of cones is the same as the harvest of other farm or orchard crops. Since the seed from cones generally is not consumed as food, but to produce seedlings, seed source and identity maintenance becomes highly important.

Most conifer forest tree species produce cones at irregular intervals. Douglas-fir produces cones at 3 to 5 year intervals and good heavy crops occur at about 7 year intervals. The quality of seed is low and the cost to produce seed is high during low and medium cone years, whereas just the opposite is true during years when cone production is high. At the same time, seed is being used up every year for reforestation. Proper seed bank inventories and planning cone harvests accordingly is critical.

PLANNING TO COLLECT CONES

The first step is to determine from the seed bank inventories what species need to be collected, from what areas and elevations, and how much seed is needed in each seed lot to replenish the seed bank. This should be updated annually, regardless whether a cone crop is on its way or not. It is also a good idea to identify those seed lots in which seed needs have become critical, so that they will be high priority in case of budget cuts or if a poor cone crop exists and collection is much more expensive.

[1/] Paper presented at the Intermountain Nurseryman's Association and Western Forest Nursery Council joint meeting, Boise, Idaho, U.S.A., August 11 - 14, 1980.

[2/] Author is Assistant Seed Orchard Manager at the Walter H. Horning Tree Seed Orchard, B.L.M., Colton, Oregon.

The next step is to inventory those collection areas in which cones need to be collected. A potential cone crop can be determined when reproductive buds have developed. A good time for Douglas-fir is April and May. During these 2 months reproductive buds have well developed or are open, depending on elevation and they are easily recognized, even on large trees, with binoculars. It is also possible at this time to identify the potential crop as light, medium or heavy. A general rule for Douglas-fir is that if cones are present only in the upper 1/3 of the crown, it is considered to be a light crop, if they are present in the upper 1/2 of the crown it is considered a medium crop and if cones are found in all parts of the crown it could be a potential heavy crop. To do this inventory it is important that one becomes thoroughly familiar with the "Reproductive Cycle" of each species inventoried.

Based on the inventory a collection plan must be developed that contains at least the following items:

1. Labor needs.
2. Equipment needs.
3. Transportation needs.
4. Prices and costs.
5. Collection methods.
6. Training.
7. Buying stations.
8. Seed extraction contracts.

The final determination for a collectable cone crop must be made as close to collection time as feasable by determining seed set and quality in the cones. This is evaluated by the cut test. The cone is sliced in half and the cut embryos are counted on one side. On Douglas-fir 5 cut embryos is considered to be a medium crop and 7 a heavy crop. After this test has been done for all collection areas the final selection of collection areas, the collection sequence, and priorities must be established.

CONE COLLECTION AND HANDLING

Collect cones as close to maturity as possible. This sometimes is difficult to do because of timing, or economic reasons. If this is the case, cones can be picked somewhat premature and through various methods, after-ripened, depending upon species. Maturity of cones must be determined prior to collection, and some of the following symptoms can be used:

1. Overall color of cones.
2. Color of scales or bracts.
3. Size of seed.
4. Color of cut endosperm.
5. Size of embryo.
6. Separation of seed from bracts.

Again symptoms change with species, and the "Reproductive Cycle" of the species to be collected must be fully understood.

The following methods can be used to collect cones:

1. Standing trees.
    a. Climbing and hand picking.
    b. Ladders and hand picking (also power ladders and man lifts).
    c. Mechanical shakers.
2. Felled trees.
3. Topping of trees.

4. Squirrel caches.

The size, location, value and species of the tree determines what method to use. Sometimes economic reasons will also influence the type of method used.

The cone is a living organism, and handling of that organism during and after collection is very critical in order to produce top quality seed. Rough handling can damage the embryo in those seeds where the embryo does not fully occupy its cavity between the endosperm. Seed also can be damaged by temperature extremes, too much moisture, or lack of oxygen. To avoid seed damage the following procedures should be observed at all times:

1. Avoid rough handling of cones.
2. Store cones in sacks loosely. A good rule of thumb is to fill a sack one-half full with cones, (or one bushel of cones in a 2 bushel sack), and then tie the sack on the very top. This leaves the cones loose in the sack, air can move through it easily, and when the cones dry there is plenty of room for expansion and the cones will not case harden.
3. If interim storage in the field or at buying stations is needed, cones must be stored on racks in a shaded area. Sacks must be stored on these racks so that air can move around them freely.
4. When shipping cones to the extractory, use open trucks, do not stack sacks more than 2 high, use racks to space out the sacks, do not transport cones during extremely hot weather, otherwise use refrigerated trucks.
5. Often extended cone storage is required prior to extraction. Storage must be well ventilated, cool and dry. Various cone shed designs are available.
6. Protect cones at all times from rodent damage. This is particularly important for small lot tree improvement cones. It is amazing how fast a squirrel can go through a bushel of cones.

CONE AND SEED IDENTIFICATION

The best cone collection and seed treatment is of no value, unless proper cone and seed identification and records are maintained. The Bureau of Land Management is using a cone tag that can be used for reforestation cone collections (large lots) as well as tree improvement cone collections (small lots). The cone tag consists of two parts, the lower part is placed inside the sack of cones and the upper part is tied to the top of the bag on the outside. Each set of tags stays with the cone and seed lot at all times, even in the seed bank storage. We are using various colors to identify B.L.M. Districts.

All small lot collections are accompanied by a list of collections, usually in numerical order by parent trees. We have a standard form for this and it is also used as a work sheet for seed extraction and testing. All seed information is key-punched off of these sheets and put into computer storage, which is up-dated annually.

CONCLUSION

In order to accomplish quality cone collections it is important to do the following:

1. Know the "Reproductive Cycle" of the tree species to collect.

2. Know your seed bank needs.
3. Inventory and evaluate possible cone crops.
4. Develop a detailed cone collection plan.
5. Pick cones at the proper maturity.
6. Pick and handle cones properly.
7. Maintain cone and seed identity and records.

PUBLICATIONS CITED

To finish up, I would like to recommend a publication that I feel would help anybody very much that is starting to collect cones:

"Guideline to Collecting Cones of B.C. Conifers", by Dobbs, B.C.; Edwards, D.G.W.; Konisha, G. and Wallington, D. Published by the British Columbia Forest Service and Canadian Foresrt Service, Joint Report No. 3, March, 1976.

USE OF SOLAR ENERGY TO DRY CONES AT THE ALBUQUERQUE TREE NURSERY

Atha Boyd Elliott[1/]

The construction and utilization of a solar energy seed extractory proved to be very efficient for drying cones in an expeditious manner with thermostatically controlled heat, plus gave us new and useful data for drying cones in the future.

Construction of the Albuquerque Tree Nursery seed extractory was completed for processing cones in the fall of 1979. The cones were processed from October 1979 to December 1979.

The extractory is 103.5 feet long running from east to west and 60 feet wide. The fiber glass cover over the roof holds the heat so it can be pulled down into the heating unit by fans on the north end of the building. There is no heat storage capacity. The north end of the extractory is equipped with thermostatically controlled dampers that will mix in outside air to maintain a maximum of 110°F. Inside the extractory there are 5 main heat units; each unit breaks into three hookups for cone drying trays. Early in the seed year temperatures in excess of 130°F were reached if only one heat unit was running. The 110°F desired temperatures could only be maintained if other fan units were running. However, this was not the case later in the seed year.

The base tray hookups, base trays and drying trays were purchased from International Forest Seed Company in Birmingham, Alabama. Each 4' X 8' drying tray was designed to hold 6 bushels of green cones.

The trays with green cones are stacked 6 high when drying. In October, cones were ready to process in 5 days; later in the year the drying time increased to 7 or 8 days. If the extractory roof had a sharper peak for more solar contact later in the season, the drying time would probably decrease. Late in the season, the dampers never opened--even with only one unit running, and with heat being directed through one hookup.

It was necessary to store some cones in the sun while waiting for space to become available in the extractory. The parking lot to the west of the extractory is black top. When drying trays were placed on pallets, cones would be fully opened only 2-3

1/ Atha Boyd Elliott, Nursery Superintendent, Albuquerque Tree Nursery

days later than in the drying system. This was only in the early part of the seed year. The lower angle of the sun later in the year caused uneven drying of the cones due to shading of the cones by the south side of the drying tray. Physically moving cones caused damage to the drying trays. The problem was alleviated by placing outside sun-dried cones in the system a couple of days.

The Nursery extractory has exhaust fans directly above the drying units that come on when the heating unit is turned on. The fans are designed to prevent the incoming pressure from destroying the walls. This is not a practical problem as the overhead door is always open when the cones are being processed to move trays in and out. The high fans remove most of the heat making it uncomfortably cold to work at times. If the fans are installed, there are at least 2 acceptable alternatives to the Albuquerque design: Switches, so the fans could be turned on independently of the heating unit if the overhead door was closed, or place the fans on the opposite wall so the heat would circulate through the building before being drawn out.

Table 1 is a summary of temperature readings taken periodically throughout the seed year. Next year a greater effort will be made to obtain more data. The benefit of the solar drying system is obvious. Even on cloudy days, there was a substantial temperature increase in the drying trays over the ambient air temperature. The first 4 temperature readings are from probe thermometers, the last is an unsheltered hygrothermograph.

The Nursery will purchase 100 additional drying trays to dry cones on the black top at the west end of the extractory. This will make double shifting possible in the event of a big seed year.

TABLE 1

TEMPERATURE READINGS OF SEED EXTRACTORY HEATING SYSTEM

DATE	TIME	WEATHER	PROBE THERMOMETER MAIN CHUTE	PROBE THERMOMETER BASE TRAY	PROBE THERMOMETER #4 FROM BOTTOM	PROBE THERMOMETER ROOF	HYGRO-THERMO-GRAPH OUTSIDE
11/5/79	1400	Clear	84	79	78	58	68
11/6/79	0840	Thin clouds	58	58	56	47	40
	1225	Overcast	75	72	75	56	56
	1535	Thick clouds	60	60	60	57	57
11/7/79	0850	Thin clouds, no direct sun. Rain in a.m.	53	53	52	46	43
11/14/79	1000	Clear	65	62	58	44	47
	1200	Clear	78	75	71	50	44
	1400	Clear	72	72	72	56	64
	1600	Clear	58	57	60	58	60
11/15/79	0830	Clear	44	44	46	42	30
	1010	Clear	46	68	66	64	48
	1200	Clear	81	78	77	54	46
	1400	Clear	77	76	78	60	63
	1600	Clear	58	60	62	60	63
11/16/79	0830	Clear	44	44	46	42	30
	1230	Clear	82	80	80	60	50
	1400	Clear	78	78	78	60	74
	1600	Clear	64	67	64	64	63
12/5/79	0830	Few high clouds	46	44	No reading taken.	38	No reading taken.
	1000	Clear	85	79		51	
	1230	Clear	83	81		58	
	1400	Clear	78	80		58	
	1600	Clear	62	66		55	
12/6/79	1100	Clear	88	88	No reading taken.	46	No reading taken.
	1300	Clear	95	94		55	
12/7/79	0810	Clear	44	46	No reading taken.	39	No reading taken.
	1000	Clear	86	84		48	
	1230	Clear	98	100		54	
	1440	Clear	88	91		58	
	1600	Clear	62	64		59	

PRODUCTION SEED PROCESSING AT PINE RIDGE FOREST NURSERY[1]

D. Altmann, P. N. Au and L. Lafleur[2]

ABSTRACT

Pine Ridge Forest Nursery processes seed from cones collected by The Alberta Forest Service and forest industry in Alberta. The seed program involves cone storage and the extraction, cleaning, grading, storage and testing of predominantly white spruce and lodgepole pine seed.

INTRODUCTION

Pine Ridge Forest Nursery processes cones collected by the Alberta Forest Service and forest industry in Alberta. Extracted seed is used for production of bareroot or container seedlings at the nursery, seeding of harvested areas, or seedling production by forest industry.

The seed program at Pine Ridge Forest Nursery involves cone storage and extraction, cleaning, grading, storage and testing of seed. Seedlots are kept separate by provenance from cone collection to seed storage.

CONE STORAGE

Cones are collected off felled trees or from squirrel caches, and shipped to the nursery in two bushel (0.70 hectolitre) burlap bags. Each bag is tagged with two identity tags, specifying name of shipper, species, area and year of collection, e.g. DG 64-5-6-74 Sw. Each shipment of cones is accompanied by a prescribed document containing detailed information about the cone collecting area.

Cones are stored in three steel-frame sheds with large, wire-screened sliding doors and asphalt floors. Each shed can hold approximately 6000 bushels (2200 hectolitres) of white spruce cones or 18,000 bushels (6500 hectolitres) of lodgepole pine cones. Pine cones are stored in their burlap bags, about eight bags high. Spruce cones are stored loosed on burlap lined self-stacking pallets, about 1½ bushels per pallet; this allows for air circulation to dry the cones and discourages molding. A bumper crop of spruce cones in 1979 forced utilization of twenty container seedling greenhouses as additional space for air-drying: cones were spread out on the floor and periodically stirred.

---

[1]Paper presented at the Intermountain Nurseryman's Association Meeting, Boise, Idaho, August 11-14, 1980.

[2]Respectively Research Forester, Production Forester, and Seed Program Supervisor at Pine Ridge Forest Nursery, Smoky Lake, Alberta.

SEED EXTRACTION

The seed extraction facility, based on a design of the Saskatchewan Forest Service, was built in 1978. It is capable of processing 50,000 bushels (18,000 hectolitres) of spruce and pine cones per year, on a one shift per day basis.

Seed extraction (and seed cleaning) are usually only carried out from November until March, on a twenty-four hours a day, five days a week schedule. This conserves energy and provides continuous employment. It also develops a versatile labour force because personnel is employed in seedling production during the remaining part of the year. The plant employs four people per eight hour shift to process cones and six people per shift to extract spruce cones. The weekly production is 3,300 bushels.

Spruce and pine cones are treated differently because scales of lodgepole pine cones are kept closed by a resinuous bond.

Lodgepole Pine

Bagged cones are moved on pallets from the cone storage sheds into the building by forklift. Cones are brought in from the cold a minimum of 16 hours before processing to ensure uniform cone temperature prior to scorching.

A hopper is filled with 30 bushels of cones by means of a conveyor, and the cones are slowly funneled through a revolving cone-shaped screen to remove needles and loose dirt. Subsequently they pass through a scorching unit, consisting of a 4-step vibrating pan and 6 gas-fired radiant heaters. This subjects the cones to a temperature of 210 - 230°C during 1¼ - 1½ minutes, and breaks the resin bond.

Cones are transported from the scorcher by means of a conveyor belt to four preheat bins. These bins utilize the exhaust heat from the kilns to precondition the cones before going into the kilns. This saves energy and time. The cones are fed into the preheat bins through a pivot-mounted auger. Water can be applied to the cones while they pass through the auger. Cones can remain for up to two hours in the preheat bins.

A batch cart on rails is filled from the bottom of a preheat bin and positioned over one of eight revolving drums in four individually controlled kilns to discharge the cones through a chute in the floor. The screened kiln drums are hexagonal in shape. Both the inside temperature of the kiln and the drum rotation speed can be varied to suit the species and seedlot being extracted. It is also possible to raise the humidity in the kiln by steam injection.

Pine cones remain in the 30 bushel capacity kiln drums for up to eight hours at a temperature of 60°C. During this time they are rotated at 3 RPM for various periods of time. Seed falling through the rotating screens is periodically conveyed by vibration into wooden catch bins outside the kiln. This step provides continuous visual evidence of the progress of the extraction process, as well as the effects of varying the rate of rotation and tumbling schedule. Removing the seed from the kiln soon after release from the cone minimizes the time that the exposed seed is subjected to heat.

Winged seed is collected from the catch bins, bagged and put in cold storage until it can be cleaned.

Spent cones are removed after the extraction cycle is completed by reversing the direction of rotation of a drum, vibrating the cones through a chute in the floor and conducting them by means of a vacuum system into a large elevated hopper outside the building. Spent pine cones are sold to contractors for use in landscaping.

White Spruce

White spruce cones open partly during the drying process in storage. They are transferred from the pallets into open carts; one cart load contains 15 bushels of "green" cones or 30 bushels fully dried cones. Cones are conveyed directly from the cart by a vacuum system to a holding bin on the floor above the kilns; dust is collected in large canvas filter bags.

A batch cart on rails is filled from the holding bin and the cones are discharged in the kiln drums, where they remain at a temperature of 40°C for varying lengths of time and are tumbled for short periods at 8 RPM. Cones of high moisture content take somewhat longer to open before releasing the seed. The average extraction cycle takes four hours.

SEED CLEANING AND GRADING

The seed cleaning and grading equipment was designed by the Hilleshog Company in Sweden, and has operated for one season. The system consists of two scalpers, a wet dewinger, a liquid separator, a seed drier, a seed sizer and four gravity separators. The objective of this process is to obtain seed of high purity and viability and a seed moisture content of 5 to 8 percent.

Scalping

Winged seed is shaken out of bags into a vibrating hopper on rails and passes through one of two scalping units, i.e. a vibrating step-sieve for lodgepole pine seed or a vibrating screen for white spruce seed, to remove cone scales, needles, dust and other debris. The vibrating screen is used for seed of both tree species until modifications of the step-sieve are completed.

Dewinging

Winged seed is transferred to a wet dewinger. This is a 130 cm diameter rotating drum, open on one end, capable of holding about 400 litres of winged seed. The drum rotates at various speeds depending on the load size and species being dewinged. A full load of approximately 340 litres of winged seed is tumbled for 40 to 45 minutes. Water is added for 4½ minutes after the drum is filled. Air is blown continuously along the side of the drum to facilitate tumbling of the seed and to prevent sticking of the wi-ged seed against the sides of the drum. The moisture causes the wings to expand and the seed drops off. The wings and some empty seeds are blown from the drum by the continuous stream of air and fall into a chute below the drum for disposal.

Liquid Separator

Seed is removed by tipping the drum and discharging the seed onto a shaking screen which removes much of the small debris. The seed passes through a small hopper and is fed by a vibrator into a cup-shaped receptacle. Here it is mixed with running water and drops through a spout about 50 cm deep into a liquid separator which contains lukewarm water. The water removes resin, fungal spores, cracked seed and fine dirt. The seed floats up to the surface and seed and water flow into a feeding device for distribution over screened trays fastened to an endless variable-speed conveyor. The speed is regulated to cover the screens with seed to a depth of 2 cm.

Drier

These screens pass through three connected drying units (each unit has room for five trays) against the direction of forced air flow, i.e. the air is cool and moist at the entry of the first drying unit and warm (32oC) and dry (2-4! RH) at the exit of the last unit. The seed dries in one to one and a half hours. The drying process is monitored by periodic testing of seed moisture content at the end of the drying cycle by means of a grain moisture tester. A moisture content between 5 and 8 percent is considered satisfactory.

Seed Sizer

Dried seed falls into a hopper and is conveyed through a suction hose to a seed sizer, which consists of a series of shaking screens of various mesh sizes. Foreign matter and seed of four sizes are separated into five fractions.

Gravity Separators

The final step of seed cleaning is accomplished by means of specific gravity separators. Each seed size if funneled into its individual separator unti. Air flowing through a separator divides the seed by weight into three fractions, i.e. filled seed, empty seeds plus wing remnants, and poorly developed seed plus miscellaneous foreign matter. The air flow can be regulated to minimize loss of good seed. Each fraction is collected in plastic bins, but only the filled seed fraction is retained and packed in clear plastic bags, separately for grade A (largest two fractions), B and C (smallest fraction).

Packing

Seed is weighed in 10 kilogram lots, an identity tag is enclosed and the bag is double-sealed by heat. Sealed bags are packed in waxed cardboard boxes that can hold 10 or 20 kilograms of seed, waxed cardboard covers of similar size are slipped over the boxes, and relevant information is written on the side of each box cover (seed-lot, species, seed grade and amount of seed). Samples for laboratory testing are taken for each seed grade before packing the seed. The seed is now ready for storage.

The whole operation is run by a crew of three per shift. The average production per eight hour shift is 140 kilograms of seed.

SEED STORAGE

The final production phase of the seed program is cold storage of seed at -18°C (0°F) and 50 percent relative humidity. A separate fire-proof concrete building has been designed to store 50,000 kilograms of seed within four freezer compartments, each with its own environment controls. It is built 1.80 metres below ground level in the side of a small hill. This results in conservation of energy and a more closely controlled environment. An important safety factor is that conditions will remain fairly stable for at least 72 hours in case of a power failure.

SEED TESTING

The seed testing laboratory is located on the second floor of the seed extraction building. It is equipped with four germination cabinets, a drying oven, an X-ray machine, precision balances and other apparatus.

Random samples of seed are taken from each of the three seed grades of every extracted seedlot and tested for purity, moisture content, germination rate and weight of 1000 seeds. X-rays are taken to detect damaged and empty seeds. Seed in cold storage is retested every second year for germination rate and moisture content.

Testing procedures are based upon the rules of the International Seed Testing Association (ISTA). A recent modification is that our germination rates are based only on the top four vigour classes according to a classification of Mr. Wang of the Petawawa National Forest Institute of the Canadian Forestry Service. This gives a better correlation with germination in the greenhouse.

Laboratory staff also stratifies seed for container seeding at the nursery.

A NEW PRECHILLING METHOD FOR TRUE FIR SEEDS[1/]

D.G.W. Edwards [2/]

ABSTRACT

Seeds of grand, subalpine and Pacific silver firs were prechilled, their moisture contents adjusted to four levels, then stored at 2°C. Non-dried seeds (45% moisture) could be stored only for 3 months before germination began. Seed quality deteriorated when seeds were stored at 45% for more than 6 months. Seeds air-dried to 35% moisture stored well for 6 months but germination began in storage after 9 months. Air-drying to 25% enabled prechilled seeds to be stored for 12 months without any significant reduction in germination. At both 35% and 25%, the effect of pre-chilling in increasing germination rate was retained. Although they did not deteriorate in storage, seeds oven-dried to 15% did not retain the prechilling effect.

INTRODUCTION

Most nurserymen have encountered, at one time or another, the problem of synchronizing the completion of seed prechilling (stratification) with the proposed sowing date. Prechilling consists of soaking the seeds in water for several hours, then refrigerating them; this treatment may last for a few weeks or several months, depending upon the species. Seed losses occur when germination begins in the refrigerator, a problem that is exacerbated when sowing is delayed. Circumstances sometimes prevent sowing all the prechilled seeds, raising yet another problem of whether to discard the surplus or dry them out and return them to storage.

Danielson (1976), reporting to the Western Forest Tree Seed Council, and Danielson and Tanaka (1978) concluded that ponderosa pine (Pinus ponderosa Laws.) seeds that had been air-dried to a moisture content of approximately 26% could be stored at 2°C for 9 months without losing seed viability or the prechill effect. Prechilled seeds of Douglas-fir (Pseudotsuga menziesii (Mirb.) Franco) air-dried to 37% moisture could be held only for 3 months before germination began in storage. Non-dried, prechilled seeds of both species, with considerably higher moisture levels, began to germinate by the third month of cold storage. An obvious key in handling prechilled seeds is the control of moisture content and if this can be done successfully, two practical possibilities suggest themselves.

1/ Paper presented at Joint Meeting of Intermountain Nurseryman's Association and Western Forest Nursery Council, Boise, Idaho, Aug. 1980.

2/ Research Scientist, Canadian Forestry Service, Pacific Forest Research Centre, Victoria, British Columbia.

i) Prechilling could be applied relatively independently of sowing date. For example, ponderosa pine seeds could begin a 1-month prechill anytime up to 9 months before sowing.

ii) Date of sowing would become flexible, since there would be a period of several months in which seeds could be stored without germination beginning prematurely.

If seeds of other conifer species could be handled in the same manner, similar advantages might occur. Other reports (Vanesse 1967; Hedderwick 1968; Barnett 1972) have indicated that prechilled seeds may be dried and stored at low temperature without losing viability. However, the effect of the prechilling treatment in stimulating germination was lost, i.e., dormancy was reinduced, when moisture contents were reduced below 10%. The research reported here examined the effects of different drying treatments on the storage life of prechilled seeds of Pacific silver fir (Abies amabilis (Dougl.) Forbes), grand fir (A. grandis (Dougl.) Lindl.) and subalpine fir (A. lasiocarpa (Hook.) Nutt.)

MATERIALS AND METHODS

Two seedlots of grand fir (Ag 2903 and Ag 2899) and one each of Pacific silver (Aa 2717) and subalpine (Al 2900) firs were provided by the British Columbia Ministry of Forests. Before experimentation began, x-ray methods were used to remove empty and insect-damaged seeds. Seeds were prechilled by soaking in water for 48 hours, drained, then refrigerated at 2°C for 28 days in plastic bags.

Prechilled seeds were dried to three moisture levels, placed in dry plastic bags and returned to cold storage at 2°C for periods up to 12 months. Some seeds were air-dried for 1-4 hours at room temperature until their moisture content had decreased to 35%. Other seeds were air-dried for 6-12 hours to 25%, while the lowest moisture level, 15%, was reached after oven-drying at 30°C. Non-dried, prechilled seeds were also stored. Their moisture content, the highest tested, varied between 40%-50% among the seedlots, but was designated as 45% for convenience. Moisture contents were calculated after drying 4 samples of 50 seeds each for 24 hours at 105°C, and expressed as a percentage of seed fresh weight by the formula:

$$\text{moisture content } (\%) = \frac{\text{fresh weight} - \text{dry weight}}{\text{fresh weight}} \times 100$$

To arrive at the target moisture contents, 10 samples of 50 seeds each from each lot were dried for 24 hours at 105°C and the mean dry weight was calculated. This mean dry weight was used with each target moisture content (35%, 25%, 15%) to calculate the fresh weight to which similar sized samples of prechilled seeds had to be dried. In drying the prechilled seeds, the fresh weights of 6-8 samples were repeatedly monitored until the desired moisture content had been achieved. Subsequent checks showed that actual moisture contents reached by this method never varied by more than $\pm$ 2.5%.

Germination was tested on 4 replications of 50 seeds each in clear, covered plastic dishes containing one layer of Kimpak, which is a highly absorbent cellulose wadding, topped by three layers of white filter paper (Whatman No. 1) and 42 ml of distilled water. Temperature alternated daily between 30°C for 8 hours and 20°C for 16 hours, with cool-white fluorescent lights on during the higher temperature period. Germinants were counted daily during the peak germination period, then every second day, up to 28 days and they were evaluated according to the International Rules for Seed Testing (Anon. 1976). Germination percentages were transformed to arcsin and subjected to analysis of variance. Means were compared using the Student-Newman-Keuls' test (Steel and Torrie 1960).

RESULTS AND DISCUSSION

Except for Pacific silver fir, for which the tests were limited by the number of filled seeds available to four storage periods, seeds were stored for 6 months without a significant reduction in average germination, irrespective of moisture level (Table 1). In subalpine fir, storage beyond 4 weeks promoted

Table 1. Average final germination (%) of four *Abies* seedlots after nine storage periods, irrespective of seed moisture level. Means within each seedlot followed by the same letter are not significantly different (P = 0.05).

Storage period	Seedlot number: Ag 2903	Ag 2899	Al 2900	Aa 2717
0 wk	62.6 ab	80.0 a	19.8 c	43.2 a
1 wk	73.1 a	73.1 a	23.5 bc	-
2 wk	70.6 a	75.6 a	23.1 bc	46.7 a
3 wk	68.5 ab	70.4 a	28.9 b	-
4 wk	71.7 a	69.6 a	30.8 b	38.7 a
3 mo	63.6 ab	72.1 a	40.2 a	42.5 a
6 mo	64.6 ab	66.7 a	42.9 a	-
9 mo	57.1 b	49.9 b	37.6 a	-
12 mo	47.3 c	47.3 b	38.6 a	-

Table 2. Average germination (%) of four *Abies* seedlots at four moisture contents, irrespective of storage period. Means within each seedlot and for each test period (14 or 28 days) followed by the same letter are not significantly different (P = 0.05). An asterisk indicates P = 0.01.

Seedlot	Days of test	Moisture Content: 45%	35%	25%	15%
Ag 2903	14	35.6 b*	72.1 a	41.4 b*	20.2 c*
	28	52.9 c*	80.5 a	68.2 b	55.8 c*
Ag 2899	14	40.7 b*	72.3 a	61.8 a	34.2 b*
	28	53.7 b*	76.7 a	76.2 b	62.2 b*
Al 2900	14	12.8 c*	43.8 a	33.3 b*	5.2 d
	28	19.9 c*	49.0 a	42.3 b*	15.7 c*
Aa 2717	14	6.3 b*	42.5 a	-	-
	28	25.1 b*	60.4 a	-	-

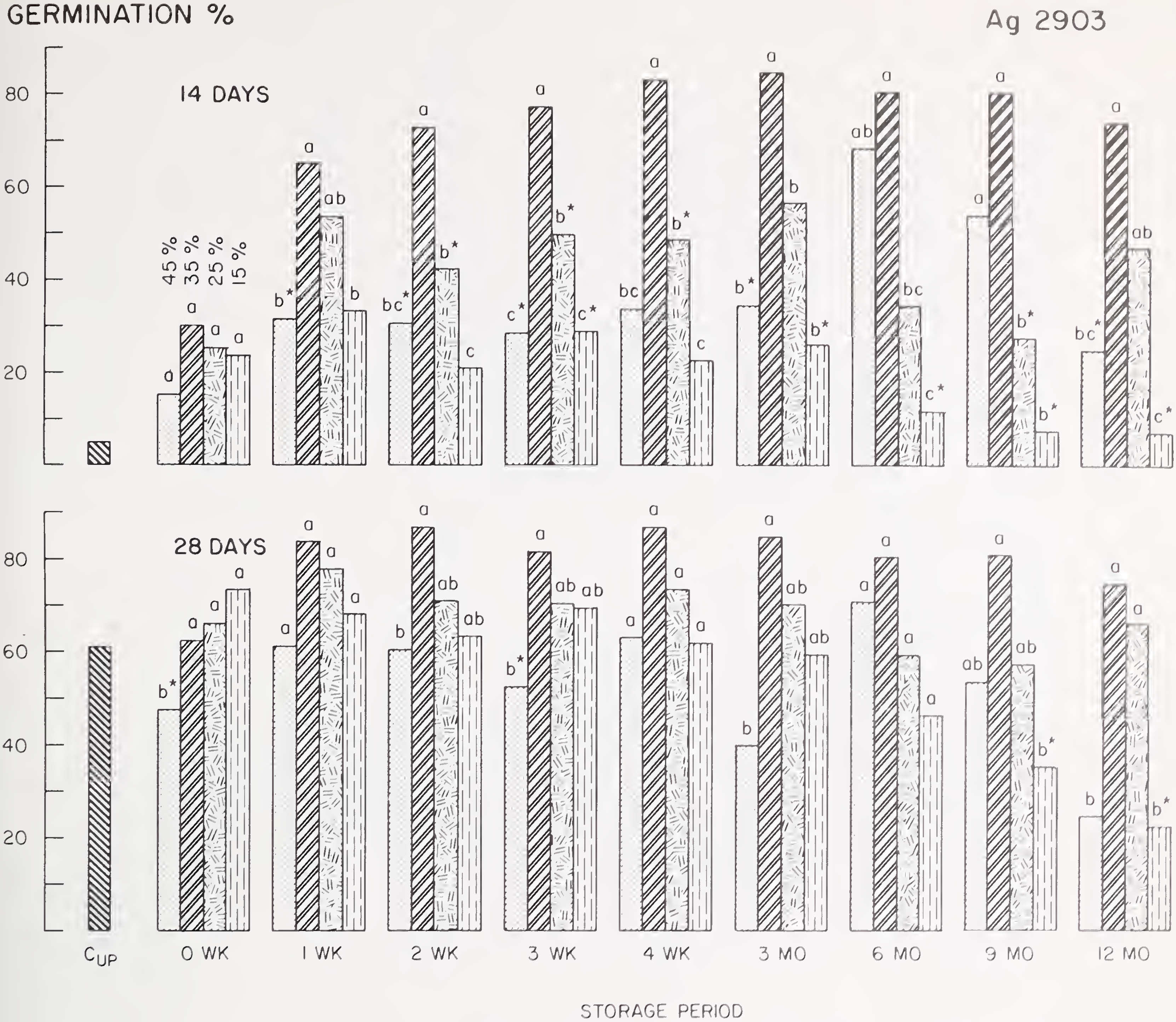


Figure 1. Effect of storage period and moisture content on germination rate (14 days) and final germination (28 days) of prechilled Abies grandis seeds (seedlot Ag 2903). C_{up}- unprechilled (unstratified) sample. Within each storage period, means followed by the same letter are not significantly different (P = 0.05). An asterisk indicates P = 0.01.

significantly higher average germination, irrespective of moisture level, a different response from that observed in grand and Pacific silver firs. This may be related to the fact that subalpine fir is a high elevation species in which a deeper dormancy may be encountered.

In all four seedlots, seeds that had been air-dried to either 35% or 25% moisture content prior to storage germinated significantly better than those oven-dried to 15% or those not dried at all (45%) (Table 2, Figs. 1-4). Irrespective of storage period, air-drying the seeds to 35% produced the best germination rate, as measured by germination percentage at 14 days of the test, and final germination (28 days) (Table 2). Compared to non-dried seeds (45% moisture), differences in all seedlots were highly significant (P = 0.01).

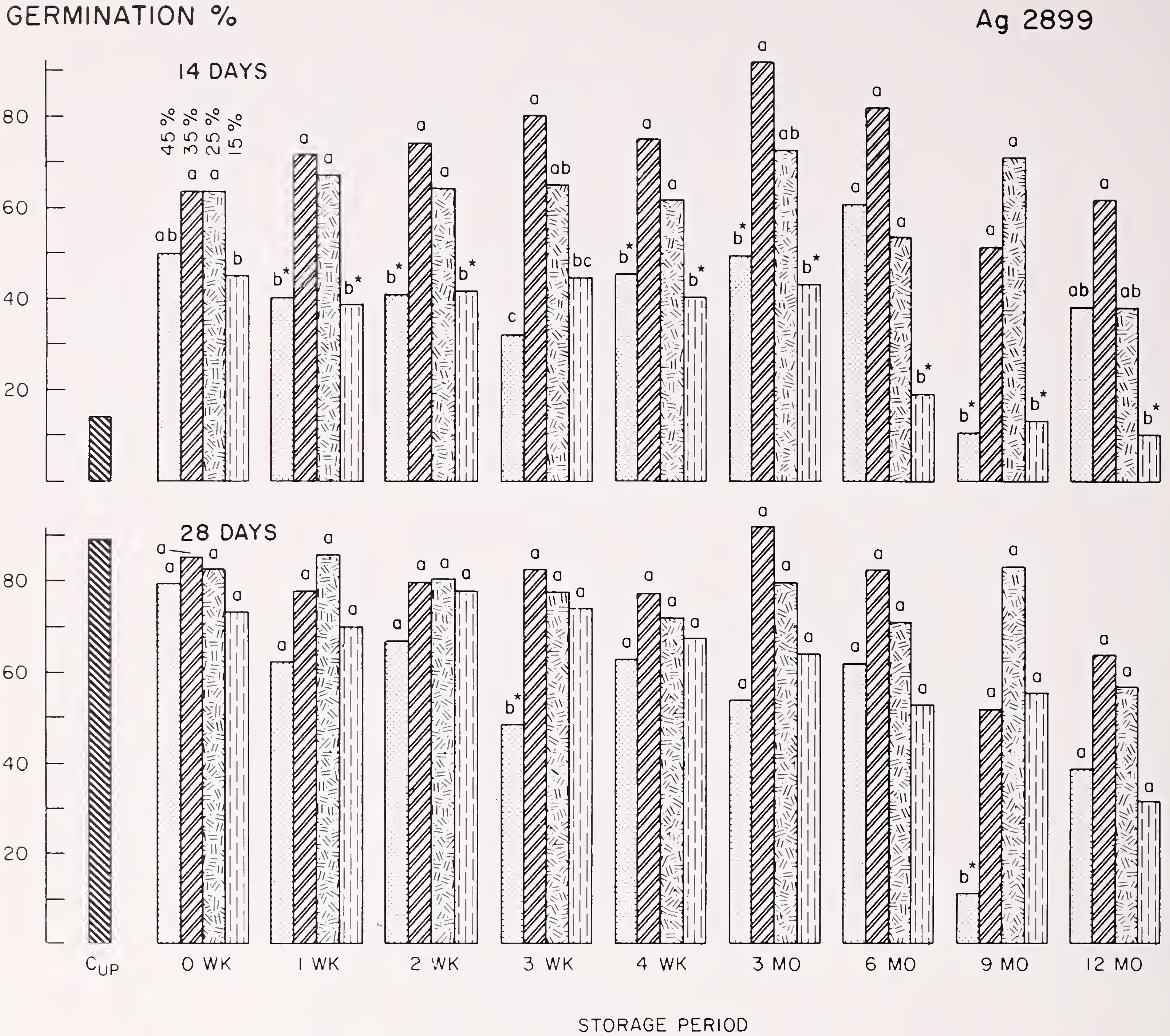


Figure 2. Effect of storage period and moisture content on germination rate (14 days) and final germination (28 days) of prechilled <u>Abies grandis</u> seeds (seedlot Ag 2899). C_{up}- unprechilled (unstratified) sample. Within each storage period, means followed by the same letter are not significantly different (P = 0.05). An asterisk indicates P = 0.01.

Storage of non-dried seeds amounted to a continuation of the initial prechill treatment, i.e., seeds stored for 4 weeks at 45% moisture in effect had been prechilled for 2 months, and considerable variability in germination was recorded in terms of variation among replications at any one storage period as well as between storage periods (Figs. 1-4). Variable germination after prechilling for several months has been observed in other studies (Edwards, unpublished data) and is probably related to high, uncontrolled seed moisture levels. In both the grand fir lots stored at 45% moisture, germination began before the 6 month storage was complete and accounted for almost all the seedlings produced at 9 and 12 months' storage. Germi-

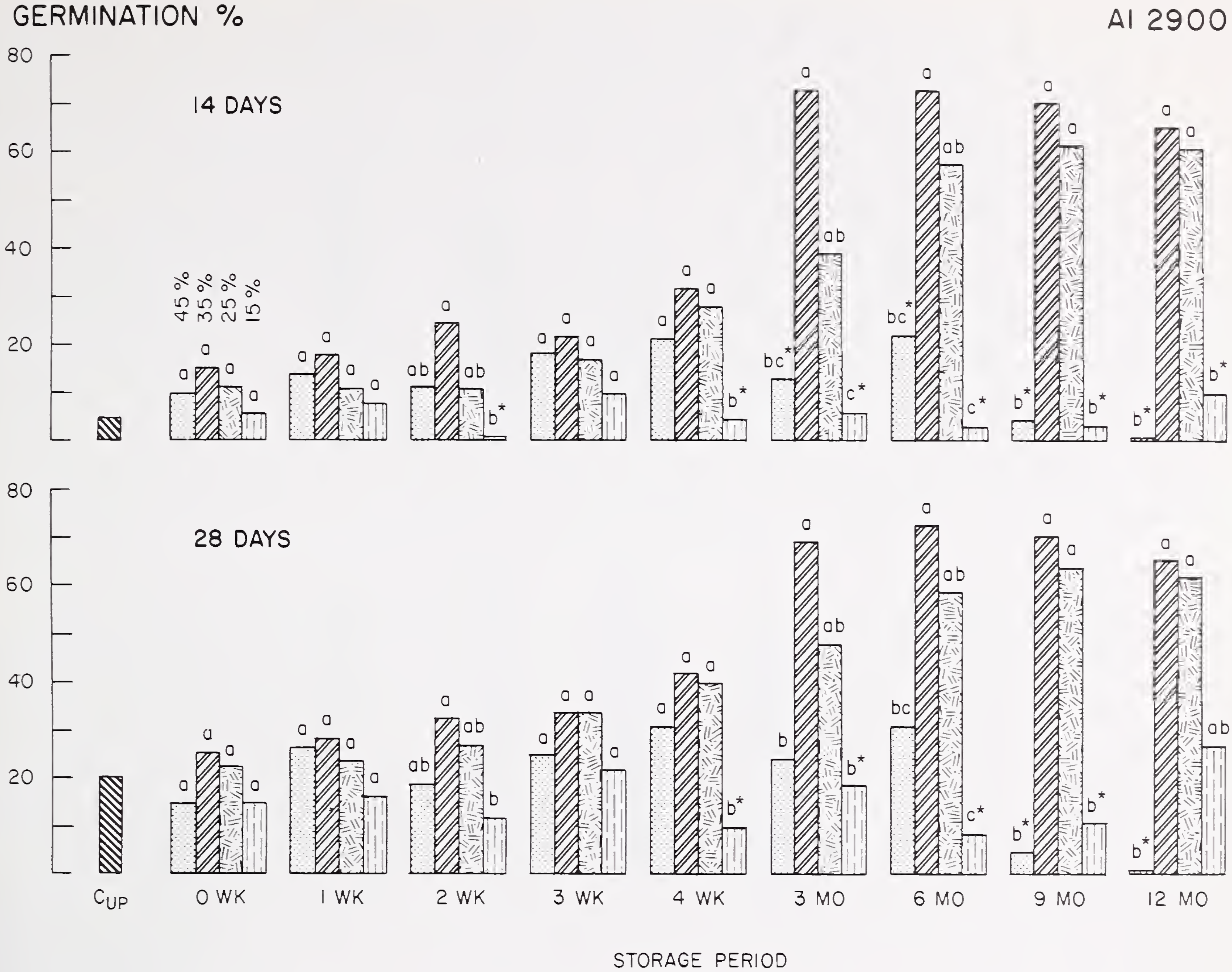


Figure 3. Effect of storage period and moisture content on germination rate (14 days) and final germination (28 days) of prechilled Abies lasiocarpa seeds (seedlot Al 2900). C_{up}- unprechilled (unstratified) sample. Within each storage period, means followed by the same letter are not significantly different (P = 0.05). An asterisk indicates P = 0.01.

nation during storage was included in total germination counts, so the reduction in final germination percentages in non-dried seeds stored for 9 and 12 months reflects a loss in seed viability. Air-drying to 35% prior to storage reduced germination during storage, but did not eliminate it. However, deterioration in seed viability at 9 and 12 months' storage was less than for non-dried seeds. Air-drying to 25% prevented emergence during storage and enabled the seeds to be stored successfully for 12 months, although germination was significantly lower than in seeds stored at 35% (Table 2). Oven-dried seeds (15% moisture) stored about as well as seeds not dried (45%), but not as well as air-dried seeds. The reduction in final germination at low moisture content was believed to be due to the reinduction of dormancy, rather than deterioration, since most of the ungerminated seeds remained viable.

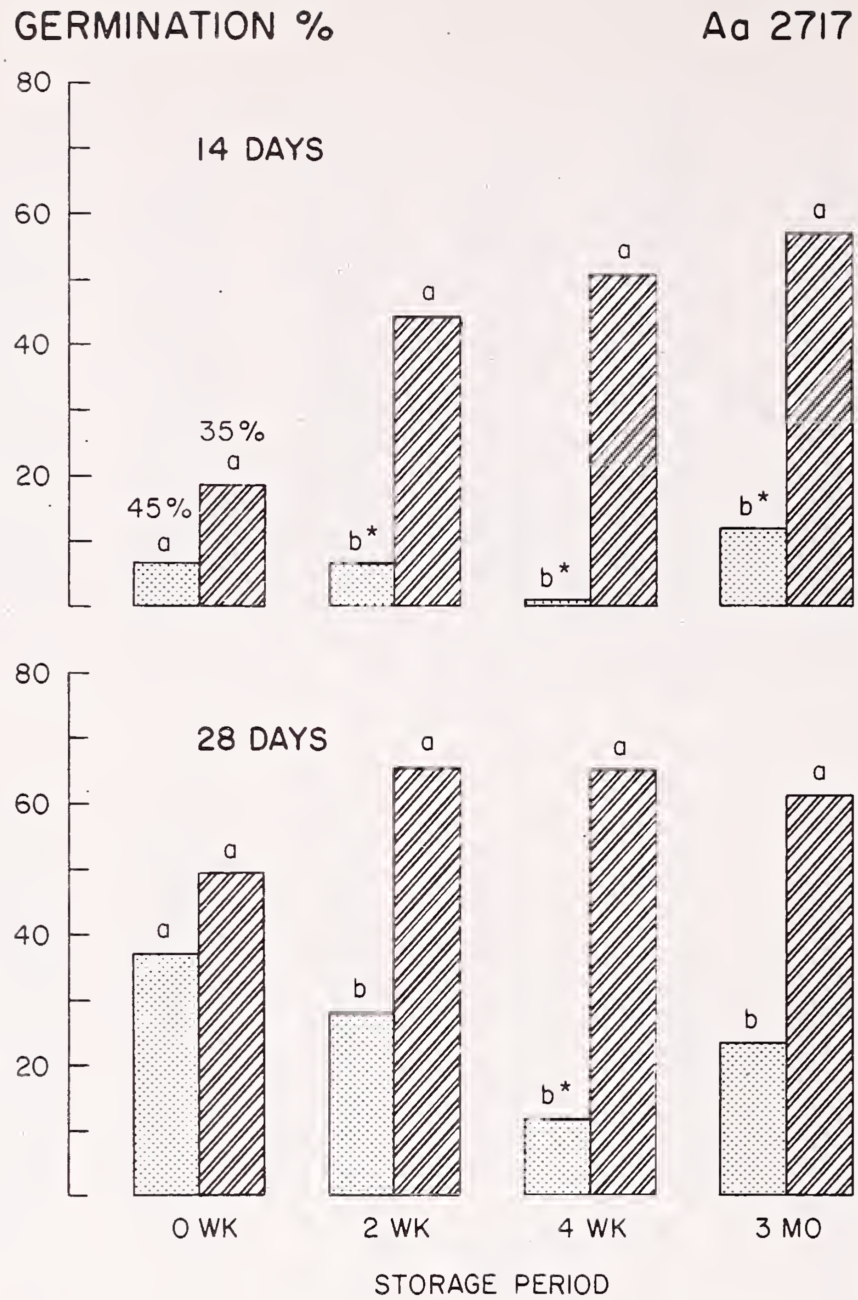


Figure 4. Effect of storage period and moisture content on germination rate (14 days) and final germination (28 days) of prechilled Abies amabilis seeds (seedlot Aa 2717). Within each storage period, means followed by the same letter are not significantly different (P = 0.05). An asterisk indicates P = 0.01.

As with most other presowing treatments, prechilling is performed to increase germination rate and it is effective in most Abies seedlots; total germination may also be increased sometimes (Franklin 1974). The 28-day prechill applied here (without drying) increased germination rate (percentage after 14 days of the test) in seeds stored for 0 weeks by a factor of between 2 and 3.5, but final germination percentages after 28 days were reduced, compared to unprechilled seeds (Figs. 1-3). When seeds were air-dried to 35% and 25%, germination rate and final germination percentage were increased, with maximum values of both parameters occurring at 35% with 3 months' storage in the two grand fir lots (Figs. 1-2) and with 6 months' storage in subalpine fir seeds (Fig. 3). Germination was so rapid when seeds were stored at 35% moisture for 3 months or longer that it was essentially complete (within 0.5% of the final germination percent) at 14 days of the test. These germination rates were between approximately 2 and 7 times greater than in seeds prechilled for 28 days (but neither dried nor stored) and were 6.5 to 17 times greater than in unprechilled seeds. In seeds not dried (45%), germination was essentially

complete at 14 days of the test only in seeds stored for 6 months or more, by which time losses in seed viability had begun. Storage for 9 and 12 months of non-dried seeds of seedlots Ag 2899 and Al 2900 reduced germination rates below those in unprechilled seeds. Tests on another 30 seedlots have confirmed that air-drying prechilled *Abies* seeds to 35% followed by 3 months' storage produces better germination than prechilling alone (Edwards and Leadem[1/], unpublished).

These results demonstrate that not only can prechilled *Abies* seeds be safely stored for periods up to 12 months without significant losses in total germination, but that air-drying stimulates germination to much higher levels than achieved by prechilling alone. Moisture content is a critical factor governing the period of safe storage. Maximum germination occurs in seeds air-dried to 35% but, since germination begins in storage, this moisture level is unsuitable for holding seeds more than 6 months. Moisture contents must be reduced to 25% to eliminate germination in storage. These observations are supported by those of McLemore and Barnett (1968) that dormancy in loblolly pine (*Pinus taeda* L.) seeds was greatest when they were stored at moisture contents between 10-18%. Dormancy was less at both higher and lower moisture contents, being least when seeds were stored above 20%. However, loblolly pine seeds with 20% or more moisture deteriorated more rapidly than those stored with 10% or less.

The increases in germination achieved by air-drying and storage should be advantageous in the nursery, even if there is no requirement *per se* to store prechilled seeds. It is not known if the procedure can be adapted for use on other tree species but this will be the subject of future work.

ACKNOWLEDGMENT

The technical assistance of D.W. Taylor is acknowledged.

[1/] British Columbia Ministry of Forests.

PUBLICATIONS CITED

Anon. 1976. International seed testing rules. Seed Sci. and Technol. 4: 3-49.

Barnett, J.P. 1972. Drying and storing stratified loblolly pine seeds reinduces dormancy. Tree Plant. Notes 23(3): 10-11.

Danielson, H.R. 1976. New seed stratification technique for ponderosa pine and Douglas fir. Proc. Joint Mtg., West. For. Nurs. Council/Intermountain Nurserymen's Assoc., 1976 (unnumbered pages).

Danielson, H.R. and Y. Tanaka. 1978. Drying and storing stratified ponderosa pine and Douglas-fir seeds. For. Sci. 24: 11-16.

Franklin, J.F. 1974. Abies Mill. Fir. IN, Seeds of woody plants of the United States. (C.S. Schopmeyer, Tech. Coord.) U.S. Dept. Agric. Agric. Handb. 450: 168-183.

Hedderwick, G.W. 1968. Prolonged drying of stratified Douglas fir seed affects laboratory germination. New Zealand For. Serv. Res. Leafl. 19, 2 p.

McLemore, B.F. and J.P. Barnett. 1968. Moisture content influences dormancy of stored loblolly pine seed. For. Sci. 14: 219-221.

Steel, R.G.D. and J.H. Torrie. 1960. Principles and procedures of statistics. McGraw-Hill, New York, 481 p.

Vanesse, R. 1967. Influence du sechage secondaire des graines de Pseudotsuga menziesii (Mirb.) Franco sur leur germination a 25°C. Bull. Rech. Agron. Gembloux 2: 551-568.

SEED PROCESSING: MANAGEMENT TECHNIQUES[1]

Frederick Zensen[2]

ABSTRACT

Management techniques to help meet the basic objective of seed extraction: High quality clean seed, are presented. Seed extraction based upon the five component management framework: Planning, Organization, Motivation, Control, and Innovation is explained.

INTRODUCTION

In recent years there has been an increased emphasis on tree seed quality for Nurseries. This is due in part to the reduction of broadcast sowing, the advent of more precise seed drills, and for the large part increased container grown stock. All this has led to the continued development of new and better seed cleaning equipment; i.e., Missoula dewinger, Barnes separator, International Forest Seed Company kilns, Oliver Destoner, and the increased use of seed monitoring equipment; i.e., H. P. Faxitron X-Ray.

My purpose is not to address the equipment improvements, but rather management techniques for seed processing (extraction and cleaning). The question might be asked, "What management techniques for seed processing? All that need be done is clean the seed." This may be sufficient for some seed processing plants and you may get adequate results, but for the reasons cited above seed processing management needs further analysis and emphasis in Nursery operations.

BASIC SEED PROCESSING PLANT

Most typical extraction facilities will follow a similar line; that is, cone reception and storage, extraction, cleaning equipment, and seed testing. This last item may or may not be accomplished at the Nursery. Naturally, the type of equipment for each step in the process will vary at each Nursery. However, the objective of each facility remains the same; to extract and clean seed. How this objective is accomplished is what I wish to discuss.

---

[1]Paper presented at Western Forest Nursery Council Meeting, Boise, Idaho, August 12 - 14, 1980.

[2]Forester, USDA - Forest Service, Coeur d'Alene, Idaho.

MANAGEMENT OBJECTIVE

The basic management objective in a seed extractory is the attainment of quality seed. Quality is defined as good vigor, high purity percent, and germination percent. The management process to achieve this objective, or any objective, may be separated into five parts: PLANNING, ORGANIZATION, MOTIVATION, CONTROL, AND INNOVATION (Batten 1969). Each part is dependent upon the other. Seed extraction easily fits into these five areas.

Planning

By July of the extraction year a fair estimate of cone crop size should be available to the manager. With this information it is then possible to plan budgeting data: cost, length of time to accomplish the job, size of crew, equipment needs, and contingencies. These items are the very least required of a good extraction plan.

Organization

Organizing the job is where crew deployment takes place. A manager should know the people in the crew and how to best deploy them; i.e., what they are best suited to do. Not all crew members function at the same levels. This is where skillful managers can best organize the utilization of their crew.

Motivation

Motivation is a very fragile word. The concept is not that difficult to understand. Webster defines motivate as (1) some inner drive, impulse, intention, et cetera, that causes a person to do something or act in a certain way; incentive, goal. Dwight Eisenhower is quoted as saying "Leadership is the ability to get a person to do what you want him to do when you want it done, in a way you want it done, because he wants to do it." I feel this is the core of seed extraction management.

Control

Control can be obtained in a few ways. As a manager you can be in the extractory checking on the crew's work constantly, or you can establish checks at various points in the process. If an accountability system is established, the spot check works rather well.

Innovation

In seed extracting this is, and must be, an on-going process. There is no single best method of cleaning seed. Each seedlot is slightly different. The size, weight, and shape of seed differs not only between lots but also within lots. The crew often times can be the best source of new ideas.

MANAGEMENT METHODS AT COEUR D'ALENE

The primary ingredient in any operation is a good crew. This is simple to state and also the answer to many management functions. Obtaining a good crew is not so easy and yet with a little effort not that difficult to achieve.

If you accept the management principle that people must have an interest in what they are doing and understand where they fit in (Boyd 1976), as well as a quantitative goal to try and accomplish, then you will agree in principle with this paper. Also, it must be understood that whether or not a group accepts management's objectives depends not only on what is demanded but also on how it is demanded. (Strauss and Sayler 1972).

My procedure at the Coeur d'Alene Nursery is as follows: The Nursery has established minimum purity standards for each species which we clean (Table 1). These standards are made known to each crew member before the start of extraction (the standards are re-evaluated each year to reflect the state of the art). In doing this I accomplish two points: (1) Management objectives are explained to the crew, and (2) A quantitative goal is presented. It is also explained that when each new seedlot is tested for purity and falls below the standard, it will be tagged with yellow flagging and must be recleaned. This, coupled with the fact that as a seedlot is processed from tumblers to scalper to dewinger to fanning mill to pneumatic separator, the operators of each piece of equipment sign off on the lot, instills quite a bit of pride in work as well as a sense of accomplishment. When the system was first instituted on those few lots that needed further processing, crew members took it as a personal affront to receive a yellow flag. That's a nice type of management problem to deal with.

Table 1.--Minimum purity standards, Coeur d'Alene Nursery

Species	Pure seed by weight
Grand fir	95%
Subalpine fir	95%
Western larch	90%
Engelmann spruce	95%
Lodgepole pine	95%
Western white pine	92%
Ponderosa pine	97%
Douglas-fir	95%

How does our crew accomplish the task of cleaning seed to a predetermined purity? The obvious answer is training and communication. This does not mean providing information. Often managers tend to equate information with understanding. This can lead to problems. Managers must communicate for the purpose of obtaining a level of understanding by crew members (Miller and Steinberg 1975). In 1978 the Coeur d'Alene Nursery processed 14M bushels of cones yielding 10M pounds of seed. This was accomplished with a neophyte crew. They had never cleaned seed before.

Each piece of equipment was explained as to its function and how it worked. Crew members were given instructions as to their equipment operations and after a short break in period told to clean seed. On those machines with different screens, starting points were established for each species and crew members were told to experiment for themselves to decide which other screens would work best, again keeping in mind the production goals. This free reign further installed a sense of accomplishment and pride in work. As notes were compared crew members began to agree with my statement that each seedlot is different regardless of species, and certain standards began to be established as starting points for cleaning. Often times they were not in agreement with my original suggestions. Innovation or new methods to clean seed are often brought out by crew members. I feel it is important that they are given the freedom to try these techniques once they have been discussed with management. A successful process which we use for pitch removal on western larch came about after such a discussion.

It was also necessary to explain to crew members what to look for in seed cleaning, which trash could be removed in certain ways, and to explain that while seed cleaning is not hard work, it does require patience. One must accept each seedlot as a challenge to clean it to a certain standard. At Coeur d'Alene the crew members also participate in both bareroot and container sowing operations and therefore have the opportunity to see the fruits of their labors or past errors as well as an understanding of where they fit in the scheme of things. Monitoring is accomplished with an X-Ray unit at various points in the process. It is done not to criticize the operators of equipment but as an instructional tool to help them accomplish management's goal of high quality seed.

CONCLUSION

By spending some time explaining to your extraction crew the importance of seed processing in the entire scope of Nursery operation, I believe you will be able to increase seed quality. I define this as increased purity, in most cases germination, and perhaps a slight reduction in yield. This reduction is due in part to more attention to trash removal and an unwillingness to let a dirty lot slide by.

Communication between people allows you to mold a good crew. It is a rare occurrence when a group of people are placed together and work well together instantly. A good manager must observe and follow the five step management process: Planning, organization, motivation, control, and innovation to achieve the desired objective.

PUBLICATIONS CITED

Batten, J. D.
1969. Tough-minded management. American Management Association.

Boyd, Bradford B.
1976. Management-minded supervision. McGraw-Hill, Inc. New York, N. Y.

Miller, Gerald R., and Mark Steinberg.
1975. Between People. A new analysis of interpersonal communications. Science Research Associates, Inc. Chicago, Ill.

Strauss, George, and Leonard R. Sayler.
1972. Personnel. The human problems of management. Prentice-Hall, Inc. Englewood Cliffs, N. J.

QUICK TEST VS. STANDARD GERMINATION TEST[1]

Ed Hardin[2]

ABSTRACT

Three "quick tests" were compared with standard germination tests on lots of Douglas fir, Pinus species, Abies species, spruce and bitterbrush. All three tests, when properly performed and evaluated, can predict viability which correlates with the standard germination tests on the same sample, except in Abies species. All "quick tests" indicate higher viability on Abies than was obtained by the standard germination test.

Germination by standard procedures under ideal conditions have long been used by nurserymen to establish viability of tree seed lots. Standard germination tests are a long, drawn-out process for most tree seed, requiring long periods of stratification under cool, damp conditions, followed many times by equally long periods in germinators under optimum conditions for the particular kind of seed. Many things can happen to seed under such conditions. Questions have been raised concerning the ability of these tests to determine the full potential of the seed. Also, because of the time required to complete the standard germination tests, the nurseryman often cannot use them in his decision process.

For these reasons, the Oregon State University Seed Laboratory has for years worked on "quick tests" which could provide information to the user more rapidly than standard germination tests. Years of effort and research have gone into refining techniques which would better correlate these quick tests with maximum germination. We feel that these correlations have been very good in recent years and would like to share a summary of some results. I hope they will acquaint you with the tests and build confidence in their results, so that they can be used to your advantage when making decisions concerning the seed you will plant to produce future tree crops.

The three tests compared here with standard germination are the tetrazolium test (TZ), which takes two days for completion, the hydrogen peroxide test, which requires eight days, and the X-ray test which can be completed during a working day. Standard germination of most tree seeds requires four to twelve weeks.

Details for conducting the tests were discussed by Rodger Danielson and are printed in your 1972 proceedings, therefore, I will not go into procedural details. If interested, you can look up the 1972 proceedings and follow his well-described instructions.

---

[1]Presented to the joint meeting of the Western Forest Nursery Council and the Intermountain Forest Nurseryman's Association, Boise, Idaho, August 12-14, 1980.

[2]Coordinator, Seed Services, Crop Science Department, Oregon State University Corvallis, Oregon 97331.

1978-79 was a good tree seed year in many parts of the West, as most of you are aware. Seed supplies were low and seed was badly needed by many nurseries. There was extreme pressure on the part of some to plant seed the same year it was collected. Some reported to me that seed had been planted without the knowledge of its viability. Various quick tests were used by some to help in decision making. The results of these tests are the data used in this paper.

I would first like to discuss the TZ test as it compares with standard germination. Tetrazolium chloride is a colorless solution. When it comes in contact with hydrogen, it forms a red pigment called formazan. Live seeds release hydrogen during the germination process. This happens very soon after water is introduced and the very first stages of germination are initiated. It was determined that if tetrazolium was introduced into seeds, those live parts would turn red and those dead would not stain. By careful observation and a knowledge of the morphology and physiology of the seed, a trained technician can determine abnormal staining from normal staining, thereby correlating the TZ test with the normal, abnormal and dead seed found in a standard germination test.

Table I compares four species of tree seed and one shrub seed on a number of different tests. Forty-seven lots of Douglas fir were tested by both TZ and standard chill and no-chill germination. Results of forty-seven tests were averaged so that a comparison could be made. The results of the TZ test were very close to both the chill and no-chill. The same was true for 45 lots of pine. In comparing 27 lots of Abies, the TZ test averaged somewhat higher than both chill and no-chill. This concerns us. Abies are a difficult species to work with, as most people working with them realize. It is often difficult to obtain high germinating lots. There seems to be considerable variation within lots. We are concerned that perhpas the proper germination conditions have not been developed to obtain the maximum germination. There may be inherent reasons, however, that deteriorate a good embryo during its germination period and in this case, the TZ may not represent what a seed would do in a planting bed. More research is needed in the case of Abies. Spruce compares favorably in the two lots compared. Many of the shrub species are dormant and difficult to germinate. Standard germination tests are not developed for some species. We have developed TZ techniques on most shrub seed being used. The TZ test on three bitterbrush lots correlated favorably with the chill germination results. These lots obviously need chilling to break dormancy since the no-chill germination test produced no seedlings.

The second test discussed is the hydrogen peroxide (H_2O_2) test. It was determined that if this material was introduced into the seed, the embryo would elongate rapidly. By evaluating the embryo development, a judgment could be made and the results could then be compared with a standard germination test.

Table 2 first compares 50 samples of Douglas fir seed tested by H_2O_2 and then followed by standard no-chill and chill germination tests. The peroxide test correlates very well with the chill but obviously some lots of Douglas fir seeds need chilling since the average no-chill was considerably below the chill method. This same trend held true for the two Pinus lots and 21 lots of Abies. It would appear that this test rather accurately predicts the potential germination of the seed.

In Table 3 we were able to compare the X-ray test with TZ and standard chill and no-chill germination test. In comparing the results of 25 lots of Douglas fir seed, it would appear that the TZ came closer to the average chill test than did the normal reading of the X-ray test. This may indicate that the X-ray is not quite as definitive as a TZ test, but is still a good indicator of the potential germination of a seed lot. In comparing the results of three Abies lots, it would appear the full

potential of the seed was not realized in the germination test. TZ and X-ray compared favorably but were much higher than the standard germination.

In summary, the results would indicate that the three "quick tests" discussed here are good indicators of potential seed viability. The Abies results did not compare as well as the other species. One can only speculate why quick tests indicate higher viability in Abies than is obtained by standard germination. With good "quick tests" available, a nurseryman should not have to sow without knowledge of the viability of his seed. More than one viability determination on high value seed may be in order so that the nurseryman can better choose lots for seeding and thereby maximize his production.

TABLE 1. Comparison of seed viability of various species as determined by TZ and standard laboratory germination tests. Results shown are averages of all samples tested.

Species	Number Samples Tested	TZ	% Germination No-Chill	% Germination Chill
Douglas Fir	47	87	86	89
Pinus Spp.	45	81	79	79
Abies Spp.	27	67	45	49
Spruce	2	97	98	97
Bitterbrush	3	53	0	52

TABLE 2. Comparison of seed viability of various species as determined by H_2O_2 and standard laboratory germination tests. Results shown are averages of all samples tested.

Species	Number Samples Tested	H_2O_2	% Germination No-Chill	% Germination Chill
Douglas Fir	50	80	74	82
Pinus Spp.	2	87	69	84
Abies	21	62	48	57

TABLE 3. Comparison of X-ray, TZ and standard germination tests conducted on various species. Results are averages of all samples tested.

Species	Number Samples Tested	TZ	X-Ray Normal	X-Ray Questionable	X-Ray Total	% Germination No-Chill	% Germination Chill
Douglas Fir	25	87	90	7	97	79	84
Abies Spp.	3	69	63	21	84	47	44

SCHEDULING IRRIGATION TO INDUCE SEEDLING DORMANCY[1]

Joe B. Zaerr, Brian D. Cleary, and James L. Jenkinson[2]

ABSTRACT

The dormancy of seedlings can be induced by increasing plant moisture stress in early summer to midsummer. Each nursery should tailor its irrigation schedule to achieve early seedling growth, then dormancy induction, and finally dormancy deepening to produce planting stock with high survival potential.

A seedlings's ability to survive in the field is closely linked to its state of dormancy (Tinus 1974; Lavender and Cleary 1974; Cleary, Greaves, and Owston 1978). When fully dormant, seedlings can easily tolerate frost, brief exposure of roots to the atmosphere during lifting, root pruning, and cold storage. Because nursery practices invariably influence seedling dormancy, knowledgeable foresters now wisely demand that nurseries insure dormancy in every seedling crop.

In Oregon's Willamette Valley, seedling top growth must be stopped by late summer or early fall to avoid fall and winter frost damage. To prevent such damage and promote both morphological and physiological quality, seedling dormancy must be induced by late summer. Although the onset of dormancy may be hastened by decreased photoperiods and reduced nutrient levels, the desired effect is most easily and consistently achieved by increasing plant water stress. The nursery irrigation schedule is, therefore, the key to inducing dormancy.

Of course, no single "magic formula" exists. Irrigation schedules must accommodate specific nursery climates and particular cultural regimes to produce plantable seedlings. This paper describes the development of optimum irrigation schedules for the Dwight L. Phipps State Forest Nursery at Elkton, Oregon.

PROCEDURES AND RESULTS

To determine optimum water regimes for 2-0 Douglas-fir, various irrigation regimes were tested annually for three years.

---

[1]Paper presented to the Intermountain Nurseryman's Association and Western Forest Nursery Council, Boise, ID, Aug. 12-14, 1980.

[2]J. B. Zaerr is an Associate Professor and B. D. Cleary is a Reforestation Extension Specialist, School of Forestry, Oregon State University, Corvallis, OR; and J. L. Jenkinson is a Forest Geneticist, USDA Forest Service, Pacific Southwest Forest and Range Experiment Station, Berkeley, CA. The mention of trade names or commercial products in this publication does not constitute endorsement or recommendation for use.

1974 Trial

Plant moisture stress (PMS) was measured with a pressure chamber[3] for three different water regimes (wet, 5 bar PMS; medium, 8 bar; dry, 15 bar) established for comparison with standard nursery practice. Treatments were begun in spring of the second growing season. The seedlings' internal moisture stress was monitored to determine the time to water and water applied when predawn PMS in seedlings exceeded the assigned treatment value.

The medium (8-bar) and dry (15-bar) regimes induced seedling dormancy in summer. Under the wet (5-bar) and standard nursery regimes, seedling tops still were growing in the fall and remained succulent in November. The dry regime reduced growth such that the resulting seedlings were too small. Predawn PMS in the dry regime did not reach 15 bar until mid-August, although average predawn PMS was much less because a week or more was required after each irrigation to again reach 15 bar. Predawn PMS of standard nursery practice closely approximated that of the wet regime and did not exceed 5 bar until late summer.

1975 Trial

Two regimes were tested in the second trial but differed from the first in that predawn PMS was increased during the growing season. Standard nursery practice was unchanged.

Treatment	Predawn PMS (bar)			
regime	May 1	Jul 1	Jul 15	Aug 15
Wet	5	5	5	10
Dry	10	15	15	15

Seedlings in the wet regime were not sufficiently dormant in fall. Seedlings in the dry regime went dormant in summer but were again too small to meet the minimum size standards for plantable seedlings. If dormancy is to be regulated, size of seedlings must be controlled by the conditions during spring and early summer.

1976 Trial

The results of the 1975 trial indicated that, for 2-0 Douglas-fir, an intermediate water regime would strike a good balance between seedling size and dormancy in fall. That intermediate regime and its modifications for 1-0 and 2-1 Douglas-fir were tested in 1976.

[3]PMS Instrument Co., Corvallis, OR 97330.

Seedling class	Predawn PMS (bar)		
	Until Jul 1	Jul 1-Aug 1	After Aug 1
1-0	5	5	10
2-0	5	7	12
2-1*	5	10	15

*On hot days, seedlings were watered as needed for cooling.

These regimes allowed adequate seedling growth in spring and early summer and induced early dormancy to virtually eliminate shoot growth in fall.

DISCUSSION

The irrigation nursery schedules developed at Elkton were adopted as standard practice to insure seedling dormancy in fall and eliminate the potential for frost damage. Subsequent nursery and field experience generated a few refinements, which were incorporated into the 1979 irrigation schedules (Table 1).

Table 1.--*Generalized irrigation schedules for various seedling classes of Douglas-fir in the Phipps Nursery, 1979*

Seedling class	Predawn PMS *(bar)*			
	Until Jul 9	After Jul 9	Aug 3	Aug 20
1-0	5	10	12	15
	Until Jun 1	Jun 1-15		After Jun 15
2-0	5	8-10		15[1]
	Until Jul 1	Jul 1-Aug 1		After Aug 1
2-1	7	10		15

[1]In seedlings held for 2-1, keep predawn PMS between 10 and 15 bar.

Our experience reinforced the following:

1.--Any schedule still is only a guide. In 2-0 seedlings, for example (Table 1), the 8- to 10-bar stress was applied later in the season if seedling growth was not sufficient, that is, beginning June 8 for certain nursery blocks, June 15 for some blocks, and June 22 for still others. Schedules based on predawn PMS also must take into account maximum stress levels reached during the day. Windy conditions and/or low humidities can substantially increase PMS for a given predawn level. Soil texture also can affect maximum water-stress levels. Consequently, each

nursery must develop its own guidelines to meet the local soil and weather conditions while considering different cultural practices and seedling size objectives.

2.--What works well at one nursery may not work at another. At the U.S. Forest Service Humboldt Nursery near McKinleyville, California, early frost is not a problem. The nursery goal--a harvest of plantable, dormant seedlings--remains the same as at Phipps, but its attainment requires a different combination of cultural practices. Undercutting seedlings in midsummer of their second year is standard practice. In a 1978 study, the best 2-0 seedlings were produced by combining a single, early-July undercut with a 5-bar predawn stress regime.[4] Further, two nursery sowings are now common, one in March-April and the other in May-June (the traditional period). For these reasons, the 1980 irrigation schedules for Humboldt (Table 2) differ from those of Phipps in several respects.

Table 2.--*Generalized irrigation schedules for various seedling classes of Douglas-fir in the Humboldt Nursery, 1980*

Seedling class	Predawn PMS *(bar)*		
	Until Jul 15	Jul 15-Sep 1	After Sep 1
1-0 Early sow	5	5	5
Late sow	5	5	5
	Until Jun 15	Jun 15-Sep 1	After Sep 1
2-0 Early sow[1]	5	6-8 (10)	5
Late sow[2]	5	5	5
	Until May 1	May 1-Sep 1	After Sep 1
3-0[3]	5	6-8 (10)	5

[1]Undercut at 15 cm in March/April and again at 20 cm in July if held for 3-0.

[2]Undercut at 20 cm in July.

[3]Undercut at 20 cm in March/April.

Humboldt's generally lower predawn PMS is effective for two reasons. First, the fall is usually mild--often warm until November; frost damage has not occurred in the nursery's history. Second, for 2-0 seedlings, the midsummer undercut effectively stimulates root growth and stops shoot growth. Midsummer removal of a major portion of the seedling's water-absorbing surface apparently substitutes for high predawn PMS in late summer. Under these cultural regimes, both 1-0 and 2-0 seedlings have consistently survived and grown well in the field (Jenkinson and Nelson 1978; Knight, Nelson, and Jenkinson 1980). At Humboldt, undercutting in early fall and/or predawn PMS over 6 to 8 bar in fall are associated with reduced field survival.

[4]Administrative study directed by William I. Stein, Pacific Northwest Forest and Range Exp. Stn., Corvallis, OR, and monitored by James A. Nelson, Humboldt Nursery.

3.--Plant moisture stress should be reduced in the fall. In another experiment, higher moisture stress applied between mid-July and late August consistently halted shoot growth and increased cold hardiness of Douglas-fir (Blake, Zaerr, and Hee 1979). Delaying onset of the stress period until late August negated the effect on hardiness. A stress level of 10 to 15 bar also induced bud set and prevented late flushing but did not increase hardiness over that of the 0- to 5-bar controls. Seedling moisture stress apparently must be alleviated in fall if the hardening process is to be enhanced.

The dormancy process must be deepened once induced. For this reason, irrigation during early fall may be necessary to insure adequate moisture to complete this phase of the dormancy cycle before temperatures become too cold (Lavender and Cleary 1974). Irrigation should, therefore, be started when firm winter buds are evident and fall rains would normally begin.

CONCLUSIONS

Irrigation control is essential for producing bare-root seedlings of Douglas-fir with high survival potentials. By programming plant moisture stress, the nursery may regulate seedling growth, induce seedling dormancy, and enhance cold hardiness. The principles are simple:

- Monitor predawn PMS in seedlings to schedule irrigation.
- Promote growth early in the season.
- Induce dormancy in late summer by increasing PMS in early summer to midsummer.
- Complete dormancy deepening and enhance cold hardiness (frost tolerance) by reducing PMS in early fall.
- Tailor the irrigation schedule to accommodate the particular nursery soil, climate, seedling class, and cultural practices.

PUBLICATIONS CITED

Blake, John, Joe Zaerr, and Stephen Hee.
1979. Controlled moisture stress to improve cold hardiness and morphology of Douglas-fir seedlings. For. Sci. 25:576-582.

Cleary, Brian D., Robert D. Greaves, and Pete W. Owston.
1978. Seedlings. In Regenerating Oregon's Forests. p. 63-97. Brian D. Cleary, Robert D. Greaves, and Richard K. Hermann, eds. Oreg. State Univ. Ext. Serv., Corvallis, Oreg.

Jenkinson, James L., and James A. Nelson.
1978. Seed source lifting windows for Douglas-fir in the Humboldt Nursery. In Proc. Nurseryman's Conf. and Seed Process. Workshop (Eureka, Calif., Aug. 7-11, 1978). p. B-77-B-95.

Knight, M., J. Nelson, and J. Jenkinson.
1980. Effects of seed source, nursery practice, lifting date and planting time on the survival and growth of planted Douglas-fir. Humboldt Nursery Admin. Study 1978-79 Rep. 23 p. Pac. Southwest For. and Range Exp. Stn., Berkeley, Calif.

Tinus, Richard W.
1974. Characteristics of seedlings with high survival potential. In Proc. North Amer. Containerized For. Tree Seedling Symp. (Denver, Colo., Aug. 26-29, 1974). p. 276-282. Richard W. Tinus, William I. Stein, and William E. Balmer, eds. Great Plains Agric. Council Publ. No. 68.

Lavender, Denis P., and Brian D. Cleary.
1974. Conifer seedling production techniques to improve seedling establishment. In Proc. North Amer. Containerized For. Tree Seedling Symp. (Denver, Colo., Aug. 26-29, 1974). p. 177-180. Richard W. Tinus, William I. Stein, and William E. Balmer, eds. Great Plains Agric. Council Publ. No. 68.

THE CRANBERRY GIRDLER IN CONIFER NURSERIES OF WESTERN WASHINGTON AND OREGON[1]

Mark E. Triebwasser and David L. Overhulser[2]

ABSTRACT

The cranberry girdler (Chrysoteuchia topiaria, Zeller) has been identified as an insect problem in some conifer nurseries. The life history of this insect and means for control are discussed.

The cranberry girdler (Chrysoteuchia topiaria, Zeller), a sod webworm, is becoming a problem in several conifer nurseries in Washington and Oregon. A sod webworm larvae was first suspected of causing damage to tree seedlings at Weyerhaeuser's Jefferson Nursery near Salem, Oregon, in 1974. In 1975 a severe outbreak occurred at the Weyerhaeuser Mima Nursery near Olympia, Washington, and has been endemic at that nursery since. The insect was positively identified in 1979 as the cranberry girdler. The larval damage has also been identified at several additional nurseries in Washington and Oregon (Table 1), although there has been some confusion concerning the casual agent. The damage now assumed to be from the cranberry girdler has been attributed to strawberry root weevil, cutworm and mice.

The damage generally occurs in scattered patches where almost all seedlings are injured. In severe infestations, losses can exceed 25 percent of the seedlings in a bed. Generally little evidence of damage from the girdler is found until the time of lifting. Then the damage is readily apparent as bark feeding on the main root at or just below ground line.

The reason for lack of early evidence of larval feeding is apparent after examining the life cycle of the cranberry girdler. The adults emerge during late June and early July. The moths can be seen flying in the trees in quick, jerky movements, especially during the morning hours. After emergence, the moths mate and the female begins laying eggs on the second day (Kamm, 1973). Egg laying continues for about one week. The eggs hatch in 12 days and begin feeding (McDonough & Kamm, 1979). The larvae are small and it is not until late August and September that they are very actively feeding. It is then that most damage occurs. During October, feeding stops and the larvae form hybernacula in which they spend the winter before forming pupae in the spring (Kamm, 1973).

---

[1]Intermountain Nurseryman's Association, Western Forest Nursery Council, Joint Meeting, Boise, Idaho, August 12/13/14, 1980.

[2]Nursery Technologist, Weyerhaeuser Washington Forest Nursery, Olympia, WA 98502, and Entomologist, Weyerhaeuser Western Forestry Research Center, Centralia, WA 98531.

Table 1.--Status of cranberry girdler at selected nurseries.

Nursery	Level Outbreak	Year First Reported	Surrounding Habitat
Greeley[1] Olympia, WA	Moderate	1979	Grassland/Pasture
I.F.A.[1] Canby, OR	None	-	Farmland
I.F.A.[1] Toledo, WA	Minor	1979	Woodland
D. L. Phipps Elkton, OR	Severe	1979	Grass/Woodland
Webster[2] Olympia, WA	Minor	1975 ?	Forest
Weyerhaeuser - Aurora Aurora, OR	Minor	1979	Farmland
Weyerhaeuser - Oregon Jefferson, OR	Minor	1974	Farmland/Grass
Weyerhaeuser - Washington Olympia, WA	Severe	1975	Grassland/Pasture
Wind River[3] Carson, WA	None	-	Forest

[1]Pers. Comm., Sally Johnson
[2]Pers. Comm., Bill Fagen
[3]Pers. Comm., Stan Meso

Movement of the moth and laying of eggs is highly dependent on type of vegetation. The moths will not move into areas where there is not suitable habitat for larvae. At the Mima Nursery most insect damage is found in 2+0 beds with a very small amount of damage in transplant beds located adjacent to 2+0 seedlings or in fields that were in 2+0 seedlings the previous year. Damage has been found in Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco), Noble fir (*Abies procera* Rehd.) and white fir (*Abies concolor* (Gord. & Glend.) Lindl.).

In mid July 1979, we had the opportunity to test a pheromone sex attractant trap specific to the cranberry girdler. By counting the number of male moths caught in the traps, a good indication of the moth population is obtained. The trap used was the Pherocon 2 trap which consists of a waterproof liner board hood over a sticky paper floor. A small rubber septa, containing the sex attractant, is attached to the center of the trap. The traps call male moths by releasing a snythetic substitute for a chemical found in extracts of the abdomen of virgin female moths.

In our test the attractant traps were placed in the following four habitats: 1) grass field, 2) 2+0 DF seedlings, 3) 1+0 DF seedlings, 4) fallow ground. Results confirmed the strong relationship between habitat and population level (Table 2). The very high population levels in grassland surrounding the nursery probably act as an infection source.

Table 2.--Male moth count by habitat type (7/12 - 7/19/79).

Habitat Type	No. Males/Trap	Mean	S.D.
Grassland	26		
	60	41	17.2
	38		
2+0 Seedlings	6		
	10	6	3.5
	3		
1+0 Seedlings	0		
	0	0	0
Fallow	0		
	1	.5	.5

Several methods for control of the insect have been used or are being tested. At the Mima Nursery, we have been using an insecticide program directed at the larvae. This last season we made three directed spray applications of Dursban®[3] at 1#AI/A. The spray was applied with a between the row applicator directed towards the stem of 2+0 seedlings. Sprays were applied in late July, late August and mid September. Results were encouraging. A control plot left unsprayed had 7 percent of seedlings damaged while sprayed seedlings in the same bed had only 0.5 percent.

The use of a directed spray is not the most desirable control method. The spray operation is slow and thus costly. Work on control of the cranberry girdler in grasses has also found that control of the larvae is the least effective method because of the difficulty in getting good penetration of the insecticide to the larvae location (Kamm, 1973). An alternative to larvae control is a spray program directed at the adult moth.

A cooperative test to find effective adult control is being conducted this year at the Phipps Nursery in Oregon and the Weyerhaeuser Washington Forest Nursery, with Jim Kamm and Les McDonough, Agricultural Research Service, USDA. Three insecticides, Diazinon®[4], Sevin®[5], and Pydrin®, are being tested for effectiveness. Large plots, approximately 5 acres each in Washington, have been sprayed with each chemical.

---

[3] Common name: Chlorpyrifos
[4] Common name: Diazinon
[5] Common name: Carbaryl

The moth population is being monitored within each chemical plot with pheromone traps. Plots will be resprayed when population levels build up.

It is interesting to note that several of the nurseries, which have little or no problem with the cranberry girdler, have other insect pests which require the use of insecticides during the critical period of June and July. For example, at Aurora we know we have cranberry girdler adults but not larvae damage. At Aurora, Diazinon® is used to control the obliquebanded leaf roller (*Choristoneura rosaceana*, Harris) during June and July.

With the availability of a sex attractant specific to the cranberry girdler, another type of control is feasible; namely, mating disruption. The cooperative is also testing this technique. A large quantity of rubber septa containing a high dosage of the sex attractant have been placed in a field. With the very high level of attractant, the male moths have difficulty in locating and mating with females. Pheromone traps have been placed in the mating disruption plot to assess its effects.

PUBLICATIONS CITED

Kamm, J. A.
1973. Biotic factors that affect sod webworms in grass seed fields in Oregon. Envir. Ent. 2(1) 94-96

McDonough, L. M. & Kamm, J. A.
1979. Sex pheromone of the cranberry girdler. Jour. Chem. Ecol. 5(2) 211-219.

REVIEW OF TECHNIQUES USED TO EVALUATE

SEEDLING QUALITY[1]

Annabelle Jaramillo[2]

ABSTRACT

The increasing need for high quality conifer planting stock has increased interest among nursery managers, silviculturists and researchers. Measurement of electrical, chemical and other characteristics that have been used to evaluate planting stock are reviewed.

INTRODUCTION

The increasing need for conifer planting stock of high quality has increased interest among nursery managers, silviculturists, and researchers in improving methods of evaluating the quality of planting stock. Nursery managers want to determine when planting stock is ready to be lifted, stored, or shipped to the planting location. They want to know how well the stock is doing in its new growing environment and to be able to relate its success or failure to cultural or handling practices at the nursery. Rising costs of equipment, chemicals, and payrolls increase a manager's need to use human and fiscal resources more efficiently. Users (silviculturists, reforestation specialists, and others) want to make knowledgeable decisions about when, where, and how to use the planting stock. They need to know the importance of timing cultural practices and of site-matching. They must know whether stock of questionable quality should be used or discarded. Furthermore, nursery managers and users need to understand each other to assure successful reforestation, and knowledge of stock quality is an important part of this communication. Such knowledge and understanding of nursery and field practices can increase the ability of both the nursery manager and user to make responsible decisions.

Researchers have directed much interest toward gathering biological data that can help the nursery manager and user in evaluating stock quality. Sutton (1980) has reviewed some of this research presented at a workshop focusing on evaluation of planting stock quality, held as part of an International Union of Forestry Research Organizations (IUFRO) workshop in New Zealand in 1979.

What is stock quality? Substantial confusion exists on this question among nursery managers, users, and researchers. The term is often used loosely: some use it to describe whether a seedling is dead or alive; others mean whether seedlings are ready to handle (i.e., whether they are in the "right" condition); still others use the term to describe whether or not seedlings are physiologically and morphologically adapted to grow on specific sites. Thus, to improve communication and subsequently

---

[1]Paper presented at the joint meeting of the Western Forest Nursery Council and Intermountain Nurseryman's Association, Boise, Idaho, August 12-14, 1980.

[2]Botanist - Pacific Northwest Forest and Range Experiment Station USDA Forest Service Corvallis, Oregon.

increase reforestation success, nursery managers, users, and researchers must clearly define "stock quality"--or at least identify what particular aspect applies for a given use.

Efforts to evaluate planting stock quality have taken many directions. Seedling physiology has been evaluated by physical parameters, such as measurements of plant water status (Cheung et al. 1975; Cleary 1971; Cleary and Zaerr 1979), electrical impedance (Glerum 1970, 1973, 1979; van den Driessche 1969, 1973a, 1976), resistance (Ferguson et al. 1975), and conductivity (Aronsson and Eliasson 1970). Quantitative measures of carbohydrate reserves (Krueger and Trappe 1967) and mineral-nutrient content (Krueger 1967; van den Driessche 1971, 1973a, 1980) have been used to describe chemical parameters. Other tests of seedling quality have included measurements of field survival and laboratory tests of survival potential (Jenkinson and Nelson 1978; Askren and Hermann 1979; Hermann and Lavender 1979).

In this paper, I will review several methods currently being used to evaluate quality of conifer planting stock. I am omitting evaluation of stock quality by morphological characteristics and the matching of stock to specific planting sites because of time limitations. Instead, I will concentrate on measures of seedling health and vigor.

DESCRIPTIONS

Tests or techniques for estimating seedling quality can be used at different levels of refinement; some may simply tell us whether seedlings are dead or alive. In areas subject to heavy frosts, estimating cold hardiness in seedlings is useful. Estimating levels of dormancy can assist the nursery manager in choosing the best lifting times. Some tests take weeks to provide information, but others can give immediate answers. No one test can tell us all we may wish to know about the seedling. We must be cautious when we use instruments as predictors of seedling quality. For example, a seedling can be dead and still have low moisture stress. We should know about differences in values that occur at different times and how to interpret these data.

ELECTRICAL MEASUREMENT OF PLANT TISSUES

Cell-wall resistance, cytoplasm resistance, and cell-membrane resistance and capacitance are components of electrical circuits in plants. Changes in the physiological status of a plant can effect changes in these components. Because electrical resistance in plant tissues is ionic rather than electronic, measures of these characteristics in plants must be interpreted carefully; variation can be influenced by factors such as seedling diameter, temperature, and moisture. The following techniques have been suggested as tools that nursery managers can use to evaluate the physiological status of seedlings.

Electrical impedance. Electrical impedance is measured by passing electrical current through a four-electrode probe inserted into plant tissue, usually at two frequencies, and expressed as a ratio. Measurements of electrical impedance have been used in studies of frost hardiness (Aronsson and Eliasson 1970; Glerum 1973; van den Driessche 1969, 1973b, 1976). In these studies, impedance measurements were made before and after plant tissues were subjected to freezing temperatures. Frost hardiness was determined by the extent of injury to the tissues, which correlated with a significant decrease in electrical impedance. Although electrical impedance measurements are nondestructive and easy to make, they are not easily translated into physiological condition of plant tissue. Electrical impedance measurements are affected by stem diameter, temperature, and tissue moisture content.

Glerum (1979) indicated that impedance measurements are of limited use in studies of water potential. Kitching (1966) also found electrical impedance measurements were not useful as an index of moisture stress. Measurements of electrical impedance appear to be promising in some areas of study, but because they vary by species and location they will be useful only when extensively studied and calibrated locally (i.e., in each nursery) for each species grown. A IUFRO project group focusing on nursery problems is currently suggesting standardization of electrical impedence curves for each nursery.

Oscilloscope square-wave apparatus. The application of a square-wave electrical pulse withoug seedling stem tissue and observation of trace forms on an oscilloscope (fig. 1) has been suggested as a tool to evaluate the condition of plant tissue

Figure 1. Oscilloscope/square-wave apparatus. Insert: electrode from oscilloscope/square-wave apparatus in seedling terminal.

(Zaerr 1972; Ferguson et al. 1975). Zaerr exposed plant tissues to freezing, steaming, and herbicides. He found that trace forms of healthy tissues differed from those of dead tissues. Although the species being observed had their own characteristic trace forms, "...differences in shape of curve for live and dead tissues of a given species were consistent." Ferguson and others (1975) noted changes in trace form (Fig. 2) of several species at different times of the year and suggested that the forms could be used to determine dormancy. These changes appeared to be related to the growth activity or dormancy of their samples. Dormancy was "measured" by time of year and not actually determined by growth tests, however. In a previous paper (Jaramillo 1978), I reported a lack of correlation between "dormant" trace forms and cold hardiness of Douglas-fir seedlings. I found that visual observation of changes in trace form could not be used as indicators of cold hardiness. Askren and Hermann (1979) took voltage measurements at three constant points of the trace--high-frequency

(HFV), mid-frequency voltage (MFV), and low-frequency voltage (LFV)--and used ratios of these measurements to typify trace forms. These ratios were used in tests of seedling survival potential. They found that "...trace character apparently does not indicate vigor as such, and thus is poorly suited for predicting survival potential." In her investigation of the relation of electrical impedance to vegetative maturity and dormancy in red-osier dogwood, Parmelee (1979) ruled out the oscilloscope/square-wave technique because of the difficulties encountered with interpretation and reliability of the square wave. Standard wave-traces would have to be established for each plant species because each tends to exhibit its own characteristic traces. In addition, slight movement of a twig in which the probes are inserted creates differences in wave form. These limitations cast doubt on a practical use of square-wave forms as visual indicators of plant physiological condition.

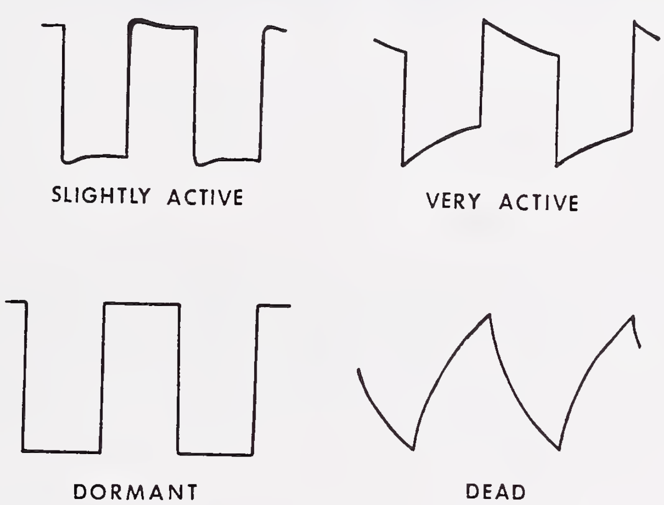


Figure 2. Square-wave trace forms indicating growth condition (Ferguson et al. 1975).

Dormancy meter. A solid-state dormancy meter (Fig. 3) has been designed for determining physiological activity of nursery stock, as a less costly substitute for the oscilloscope/square-wave apparatus. The Missoula Equipment Development Center's engineers have determined "...that an instrument which measures the ratio of voltage at 500 hertz and at 10 kilohertz gives basically the same performance..." as the oscilloscope/square-wave apparatus[3]. Preliminary tests[4] that I made comparing dormancy meter readings with square-wave trace form showed little or no correlation between the two instruments. I did not compare meter readings with actual seedling physiological status. A more thorough investigation of this relationship should be made before the instrument is recommended for operational use.

---

[3]February 1977. Report 7741 2505. Equipment Development Center, USDA-FS, Fort Missoula, Missoula, Montana.

[4]Jaramillo, Annabelle E. 1978, 1979. Office Reports: Comparison of Oscilloscope/Square Wave Apparatus and the MEDC Dormancy Meter.

Figure 3. Dormancy meter designed by Missoula Equipment Development Center, USDA Forest Service.

PHYSIOLOGICAL WATER STATUS

Energy status of water in plants results from transpiration, evaporation, and other factors. Water status in a soil-plant continuum is dynamic, and the water is rarely in equilibrium with that in surrounding areas. Because the process is dynamic, measurements must be interpreted carefully by someone knowledgeable in plant-water relations.

Because plant responses to water stress are closely related to the energy required to remove a unit of water from soil, instruments used to measure soil-water status have been investigated as possible tools to estimate plant-water status. I will describe only techniques that measure water inside plants, however.

<u>Psychrometric measure of water potential</u>. Water potential of a small sample of plant tissue is measured by condensing water from the atmosphere in a psychrometer chamber, in which the tissue is placed, on to a measuring junction (thermocouple). Measurement of output voltage (on a microvoltmeter connected to a psychrometer) across the thermocouple is a function of the water potential in the psychrometer and ambient temperature. Stein and Jaramillo[5] tested water potential of Douglas-fir needles and found that the psychrometric measurements were too variable to be used as indicators of seedling quality. The sensitivity of the psychrometer (fig. 4) to fluctuating ambient temperatures, the lengthy periods needed to calibrate the instrument and make observations, and the need to establish standard curves for the tissues being tested make it highly impractical as a predictive tool.

---

[5]Stein and Jaramillo, unpublished data, on file at FSL.

Figure 4. Equipment needed for water-potential studies. Psychrometer chamber apparatus is connected to a microvoltmeter. A paper disc, saturated in tissue water extracted by maceration is inserted in the psychrometer chamber. The equipment is calibrated by known standards.

Freezing-point depression. Carey and Fisher (1969) and Fisher (1972) have described a small, portable instrument that measures the freezing-point depression of plant tissue. It consists of a small freezing chamber mounted on the cold side of a Peltier battery. They suggest that "...freezing-point depression measured immediately after ice crystals begin to form in plant tissue in the field could give on-the-spot estimates of plant water stress." This has advantages over the psychrometric method because it is less time consuming, less expensive, and can be used on more types of plant tissue. The practicality of both water-potential and freezing-point depression measures need to be investigated more intensely for conifer seedling tissues before they can be suggested as useful tools for evaluating stock quality.

Pressure-chamber (pressure-bomb) technique. At a recent IUFRO Conference, Cleary and Zaerr (1979) described the pressure-chamber technique used to evaluate plant water status. In the instrument (fig. 5), the negative potential in the xylem of the plant is balanced with the positive pressure of a chamber. A sample is cut from a seedling and placed in the chamber with the cut end exposed through the chamber cover. Pressure is slowly increased in the chamber until water is forced back to the cut surface. This pressure is an estimate of plant moisture stress (PMS) in bars. Drawbacks of the technique are that values of zero stress levels are not obtainable and that it requires compressed gas, which can be potentially dangerous if not used carefully. The pressure chamber technique is relatively fast and easy and gives good estimates of seedling water status. But it should not be the only tool used to determine stock quality, because water status does not always tell the whole story. The pressure chamber is currently being used at many nurseries in the Pacific Northwest for regulating irrigation schedules and determining when stress is too high for lifting and handling. Many silviculturists also use pressure chambers for checking stock quality in the field.

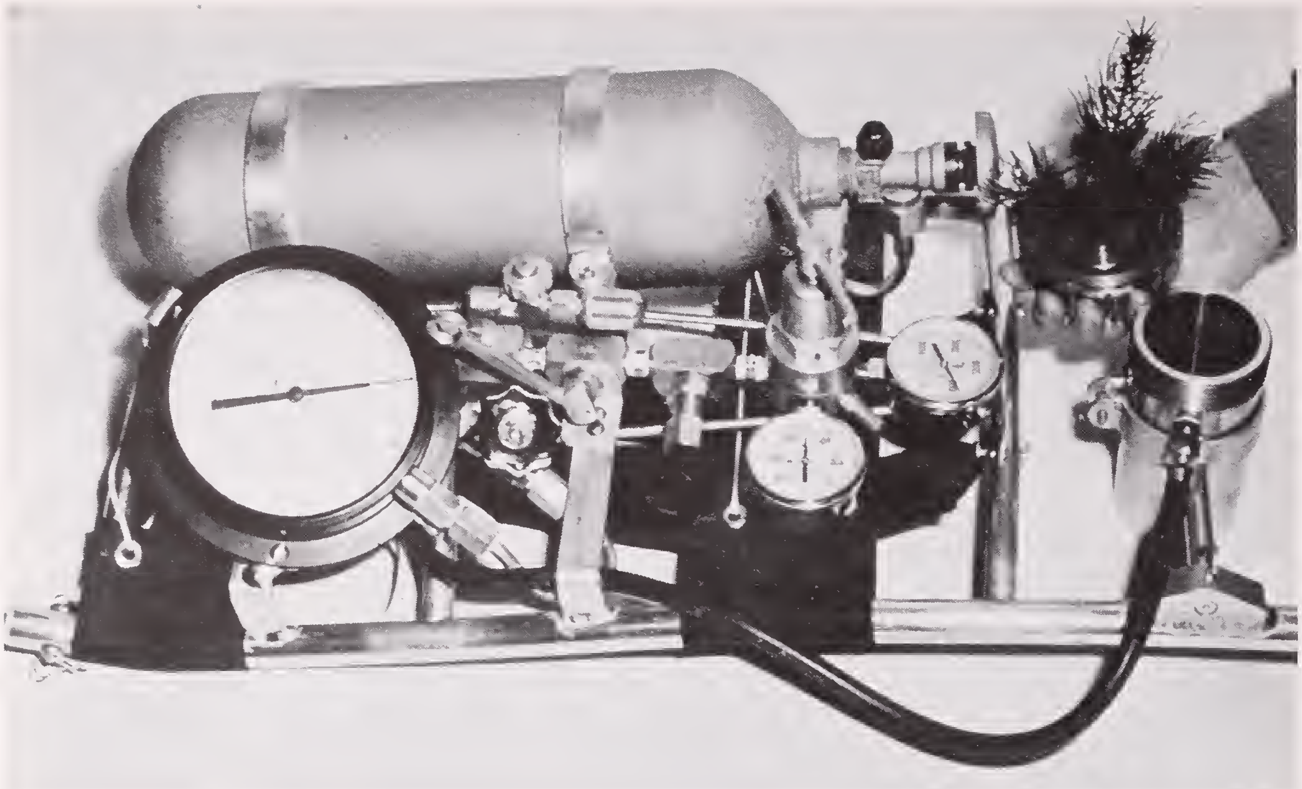


Figure 5. Pressure-chamber apparatus used to measure moisture stress using compressed gas.

Hydraulic Press. A hydraulic press has been developed (fig. 6) for measuring leaf-water stress and soil-water content. Measured hydraulic pressure beneath a flexible membrane is used to press a leaf or other plant tissue against a plexiglass window. As pressure is applied, water appears at the cut edge of the stem or leaf. Additional pressure causes changes in leaf color. Water stress is characterized by the pressure required to produce the color change accompanied by continual water excretion. Advantages are that the instrument can make measurements rapidly and that it does not require a compressed gas supply. Disadvantages reported by Cleary and Zaerr (1979) are: the end point is indefinite; precision is low; the instrument must be calibrated with a pressure chamber; foliage of different ages gives different results; and a very large sample size is required for acceptable accuracy. Until further data on the hydraulic press are reported, operational use of the technique is questionable.

Figure 6. Hydraulic press used to measure moisture stress.

CHEMICAL CHARACTERISTICS OF PLANT TISSUES.

Foliage nutrient content and carbohydrate reserves have been the most commonly studied chemical characteristics of seedlings. Visual clues--such as needle chlorosis, needle curl, and stunted growth--can tell us that some mineral element vital for growth is deficient. Knowledge of the mineral nutrient status of seedlings can tell us whether to apply or delete fertilizers to insure optimum growth of seedlings. Similarly, knowing something about carbohydrate levels at different times of the year helps establish handling practices that take advantage of carbohydrate reserves within the seedlings. We must know how to interpret the data and how they relate to planting stock quality, however.

Foliage nutrient content. Foliage nutrient content has been suggested as a predictor of seedling survival. Wakely (1949) suggested that evidence of a direct relation "...between chemical (nutrient) differences in seedlings..." and "...differences in survival and growth after planting..." was needed to establish foliage nutrient content as a predictor. Switzer and Nelson (1963) found that for 1+0 loblolly pine seedlings, a linear relation existed between height at 3 years in the field and foliar nitrogen content at lifting. Regression analyses indicated, however, that field survival could not be predicted by foliage nutrient content. Heiner and Lavender (1972) found that foliar calcium/potassium ratios of 2+0 Douglas-fir seedlings did not correlate with field survival. In their investigation of 1+0 seedlings of several pine species, Gilmore and Kahler (1965) found no relation between field survival and foliage contents of nitrogen, phosphorus, or potassium. Although nursery fertilization does enhance seedling growth, foliage nutrient content at time of lifting has not been useful as a predictor of field survival. In addition to a lack of correlative data, assessment of foliage nutrient content is further hampered by the need for specialized equipment, a skilled investigator, and lengthy lapse times for results. Although many studies have been aimed at determining desirable nutrient levels within seedlings, no standardization of these levels and few correlations with field performance have been made. These factors limit the use of nutrient status as a predictor of stock quality.

Carbohydrate reserves. Krueger and Trappe (1967) observed substantial seasonal changes in carbohydrate concentrations of Douglas-fir seedlings at the USDA Forest Service Wind River Nursery. In the fall when top growth stopped, sugar reserves gradually increased. Maximum concentrations occurred with the coldest weather. A late winter decrease in sugar concentrations coincided with an increase in starch concentrations. They suggested that information on carbohydrate reserves might be used in selecting appropriate times to handle planting stock, which might improve survival in the field. Like mineral nutrient content, carbohydrate reserve data are useful only if we have standards for comparison. Further work is needed before information on carbohydrate reserves in conifer seedlings can be used as a predictive tool. The need for specialized equipment, skilled personnel, and lapse times for results also makes operational use doubtful.

GROWTH-EVALUATION TECHNIQUES

Jenkinson and Nelson (1978) reported the use of root-growth capacity (RGC) of Douglas-fir seedlings as a predictor of field survival. RGC, previously termed root-regenerating potential (RRP), is the seedling's ability to initiate new roots and elongate existing roots under conditions favorable for growth. RGC is estimated by measuring new root growth in controlled favorable environments for a specific period. Jenkinson and Nelson (1978) found that field survival was associated with RGC values. RGC appears promising as one method of evaluating quality of planting stock. Additional standards of RGC for different species, seed sources, and nurseries must be established and correlated with field performance, however.

Hermann and Lavender (1979) encouraged testing of seedling vigor as a measure of stock quality. This requires maintaining seedlings under constant conditions in a growth room and observing bud flush and survival. A random sample is selected from a nursery lot for testing. Half of the sample is kept as a control (not stressed), the other half is stressed by exposing bare roots and shoots to 90°F and relative humidity of 30 percent for 15 minutes just before potting the seedlings. (This stress testing can be varied according to the intended planting site.) All seedlings are potted and then kept for at least 4 weeks at 70°F (±5°F) with a 16-hour photoperiod of 500 foot candles. In 4-6 weeks, bud flush can be used as an indicator of vigor. An additional sample should be monitored in the field. Hermann and Lavender suggest that if a lot is deemed satisfactory in vigor tests but has poor survival in the field, seedlings may not have been properly handled during storage, transport, or planting. If field survival is much better than in the growth room, the procedures for that particular vigor test may have been conducted improperly. Poor survival in the field and the growth room can indicate a problem in the nursery environment or cultural practices.

DISCUSSION

I believe the most successful evaluations of planting stock now available are tests of seedling vigor and field survival. Although they do require time, they integrate all the various conditions and quality factors and give us information that can be useful for suggesting future nursery and planting practices. We can include other types of testing to determine specific characteristics and to search for more rapid determiners of overall seedling quality.

Coniferous tree seedlings--like all plants--are complex systems in which many internal processes occur and interact. These systems are affected by the environment in which the seedlings grow. A multitude of studies is directed at unraveling and understanding these complex systems. The techniques I have reviewed here are a small part of these investigations. Measures of the physical properties of seedlings have been attempted through studies of electrical impedance, resistance and capacitance of seedling cells and tissues, and plant moisture status. Analyses of foliage nutrient content and carbohydrate reserves have given us much information about the biochemical nature of seedlings. Tests of growth and seedling vigor are important for evaluating stock quality.

We should not depend on one method alone to tell us everything we want to know about seedlings. We have to look at what a combination of methods tell us and continue to look for new tools to evaluate planting stock quality. My fantasy is to have, some day, a tricorder (the little black box carried by Mr. Spock, science officer on the Starship Enterprise) to carry into a greenhouse or out to the nursery bed and have it tell me, at the push of a button, all there is to know about a seedling and its potential. In reality, we do not have such a single tool--and probably never will. But the tools we do have can be used separately or jointly to gather the information we need about planting stock to improve our reforestation efforts.

REFERENCES CITED

Aronsson, A., and L. Eliasson.
1970. Frost hardiness in Scots pine (*Pinus sylvestris* L.) I. Conditions for test on hardy plant tissues and for evaluation of injuries by conductivity measurements. Stud. For. Suecica. 77, 30 p.

Askren, Catherine, and Richard K. Hermann.
1979. Is the oscilloscope technique suitable for predicting survival of planting stock? Tree Plant. Notes. 30(4):7-11.

Cary, J. W., and H. D. Fisher.
1969. Plant moisture stress: A portable freezing-point meter compared with the psychrometer. Agron. J. 61:302-305.

Cheung, Y. N. S., M. T. Tyree, and J. Dainty.
1975. Water relations parameters on single leaves obtained in a pressure bomb and some ecological interpretations. Can. J. Bot. 53:1342-1346.

Cleary, Brian D.
1971. The effect of plant moisture stress on the physiology and establishment of planted Douglas-fir and ponderosa pine seedlings. Ph.D. Thesis, Oreg. State Univ., Corvallis. 85 p.

Cleary, Brian, and Joe Zaerr.
1979. Use of the pressure chamber technique to monitor and evaluate seedling water status. IUFRO workshop: Techniques for evaluating planting stock quality. August, 1979. Rotorua, Christchurch, New Zealand. 13 p.

Ferguson, Robert B., Russell A. Ryker, and Edward D. Ballard.
1975. Portable oscilloscope technique for detecting dormancy in nursery stock. USDA-FS Gen. Tech. Rep. INT-26. 16 p.

Fisher, H. D.
1972. An inexpensive method of determining plant moisture stress using freezing-point depression. Soil Sci. 113(6):383-385.

Gilmore, A. R., and L. H. Kahler.
1965. Fertilizers and organic additives in pine nursery seed beds: Effect on field survival, field growth, and chemical content of foliage. Tree Plant. Notes. 73:21-27.

Glerum, C.
1970. Vitality determinations of tree tissue with kilocycle and megacycle electrical impedance. For. Chron. 46(1):63-64.

Glerum, C.
1973. Annual trends in frost hardiness and electrical impedance for seven different coniferous species. Can. J. Plant Sci. 53(4):881-889.

Glerum, C.
1979. Electrical impedance techniques in physiological studies. IUFRO workshop: Techniques for evaluating planting stock quality. August, 1979. Rotorua, Christchurch, New Zealand. 15 p.

Heiner, Terry D., and Denis P. Lavender.
1972. Early growth and drought avoidance in Douglas-fir seedlings. Res. Pap. 14, For. Res. Lab., Oreg. State Univ., Corvallis. 7 p.

Hermann, Richard K., and Denis P. Lavender.
1979. Testing the vigor of coniferous planting stock. Res. Note 63, For. Res. Lab., Oreg. State Univ., Corvallis. 3 p.

Jaramillo, Annabelle.
1978. An integrated study of nursery stock conditioning: Oscilloscope readings and cold hardiness. Conf. and Workshop Proc., October 1978, West. For. Nursery Counc. and Intermt. Nurseryman's Assoc., Eureka, Calif., 1978. p. B106-B116.

Jenkinson, James L., and James A. Nelson.
1978. Seed source lifting windows for Douglas-fir in the Humboldt Nursery. Conf. and Workshop Proc., October 1978, West. For. Nursery Counc. and Intermt. Nurseryman's Assoc., Eureka, Calif., 1978. p. B77-B95.

Kitching, R.
1966. Investigating moisture stress in trees by an electrical resistance method. For. Sci. 12:193-197.

Krueger, Kenneth W.
1967. Foliar mineral content of forest- and nursery-grown Douglas-fir seedlings. USDA For. Serv. Res. Pap. PNW-45. 12 p.

Krueger, Kenneth W., and James M. Trappe.
1967. Food reserves and seasonal growth of Douglas-fir seedlings. For. Sci. 13(2):192-202.

Parmelee, Kathleen.
1979. The relationship of electrical impedance to vegetative maturity and dormancy in red-osier dogwood. Masters thesis. Oreg. State Univ., Corvallis. 87 p.

Switzer, G. L., and L. E. Nelson.
1963. Effect of nursery fertility and density on seedling characteristics, yield, and field performance of loblolly pine (*Pinus taeda* L.). Proc. Soil Sci. Soc. Am. 27:461-464.

Sutton, R. F.
1980. Techniques for evaluating planting stock quality: Int. Union For. Res. Org. (IUFRO) workshop, New Zealand, August 1979. For. Chron. 56(3):116-120.

van den Driessche, R.
1969. Measurement of frost hardiness in two-year old Douglas-fir seedlings. Can J. Plant Sci. 49:159-172.

van den Driessche, R.
1971. Response of conifer seedlings to nitrate and ammonium sources of nitrogen. Plant and Soil 34:421-439.

van den Driessche, R.
1973a. Different effects of nitrate and ammonium forms of nitrogen on growth and photosynthesis of slash pine seedlings. Aust. For. 36(2):125-137.

van den Driessche, R.
1973b. Prediction of frost hardiness in Douglas-fir seedlings by measuring electrical impedance in stems at different frequencies. Can, J. For. Res. 3(2):256-264.

van den Driessche, R.
1976. Prediction of cold hardiness in Douglas-fir seedlings by index of injury and conductivity methods. Can. J. For. Res. 6(4):511-515.

van den Driessche, R.
1980. Effects of nitrogen and phosphorus fertilization on Douglas-fir nursery growth and survival after outplanting. Can. J. For. Res. 10:65-70.

Wakeley, Philip C.
1949. Physiological grades of southern pine nursery stock. Proc. Soc. Am. For. 1948:311-322.

Zaerr, J.B.
1972. Early detection of dead plant tissue. Can. J. For. Res. 2:105-110.

TECHNIQUES OF QUALITY CONTROL FOR

SEEDLING LIFTING OPERATIONS[1]

John H. Hinz[2]

ABSTRACT

Describes methods and rational for monitoring seedling quality during lifting operations at a Southern Idaho forest nursery. Includes descriptions of methods for measuring dormancy and plant moisture stress and provisions for protection of stock during lifting and transport to packing shed.

INTRODUCTION

Since the reforestation process is especially sensitive to any mistakes made in the rearing or handling of planting stock, the prudent nursery manager is well advised to monitor the effects of his/her practices upon the quality of the finished product. Each phase of nursery operation offers its own unique set of problems and opportunities with regard to quality control. This paper describes the quality control techniques used at a Southern Idaho forest nursery during a particularly critical phase of the reforestation process: seedling lifting.

Built in 1960 as the U.S. Forest Service nursery for the Intermountain Region (R-4), Lucky Peak provides the majority of the seedlings used for reforestation projects in that region as well as contributing to the efforts of the Southwest Region (R-3), the Pacific Northwest Region (R-6) and several other agencies, including BLM, and Idaho Fish and Game. Production in recent years has been on the order of 9 to 11 million 2-0 seedlings. With the reduction in reforestation backlogs, and with the nursery at Albuquerque producing seedlings for R-3, Lucky Peak production will probably stabilize at somewhere between 6 and 8 million seedlings per year. Species produced include most of the common western conifers, particularly lodgepole pine, Douglas-fir, and ponderosa pine, as well as several species of native shrubs. Most seedlings are spring-lifted, though a small fall lift (1-2 million seedlings) is usually conducted.

---

[1]Paper presented at joint meeting of Intermountain Nurseryman's Association and Western Forest Nursery Council, Boise, Idaho, August 12-14, 1980.
[2]Forester, U.S.D.A., Forest Service, Boise National Forest, Lucky Peak Nursery, Boise, Idaho.

PROCEDURES

Lifting is done primarily with contract labor and proceeds as follows: Seedlings are undercut to a depth of about twelve inches with a standard tree-lifting blade drawn by a crawler tractor. This is followed by a wheel tractor drawn Egedal lifter/shaker which vibrates to loosen the seedlings in the soil. The lifting crew then lifts the seedlings by hand, shaking the soil free from the roots and placing them immediately into plastic boxes layered with wet burlap. As soon as possible these boxes are loaded onto trailers and taken to the seedling coolers, where they are segregated by source and stored at 34°F until they can be graded and packed.

Quality controls associated with the lifting operation can be seperated into two general categories:

1. Monitoring the physiological condition of the seedlings.
2. Protection from injury.

The primary concerns with respect to physiological condition of seedlings are dormancy and plant moisture stress. The conventional wisdom in reforestation is that, other things being equal, seedlings which are lifted during their dormant period are better able to withstand the shock of lifting, packing, storing, and planting than are seedlings which are lifted during a period of activity.

At Lucky Peak Nursery seedlings usually enter dormancy in early to mid-November, breaking dormancy anywhere from late February to mid-March. Ideally, lifting would be done sometime between these two dates. Unfortunately, Lucky Peak is situated such that, very shortly after the seedlings enter dormancy the soil freezes, preventing lifting. Usually it remains frozen until just a few days prior to the time when the seedlings break dormancy in the spring. Thus, if seedlings are to be lifted while dormant, the lifting must be done in a very short period of time.

Because of this situation, seedling dormancy is monitored very closely as the season for fall lifting approaches so that lifting can begin as soon as the seedlings are dormant. For the past several years a portable oscilloscope and square wave generator has been used to determine the degree of dormancy within the seedlings. This technique (Ferguson, Ryker, and Ballard, 1975) requires the interpretation of a square wave pattern on an oscilloscope screen which, having been transmitted through the seedling with a needle-like probe, changes shape in response to the physiological activity within the plant. Though its validity as a measure of dormancy has not been universally accepted by plant physiologists, the oscilloscope technique provides a useful guide to the practicing nursery manager in deciding when to start lifting operations.

Since 1979 we have also been using the Missoula Equipment Development Center dormancy meter as a supplement to the oscilloscope. This instrument utilizes a probe similar to that on the oscilloscope, but has the advantage that it gives numerical readouts supplemented by lights indicating "Dead", "Dormant", or "Active", so that interpretation of wave patterns is not necessary. Being neither an electrical engineer nor a plant physiologist I am ill-equipped to comment upon the validity of this device in an absolute sense, however, I have observed that readings taken with the dormancy meter generally agree with oscilloscope readings taken on the same plants.

In addition to using the oscilloscope and dormancy meter to determine when to commence fall lifting operations, these instruments are also used to monitor the state of seedling dormancy during the spring lift. While an indication that seedlings are breaking dormancy during the spring lift will not allow us to lift them any faster (this is usually controlled by field and weather conditions), such information is useful in that it can tell a receiving forest that a given lot of seedlings may be particularly sensitive to mishandling.

Plant moisture stress is also closely monitored during lifting operations. Though a pressure bomb is available at Lucky Peak, it is used for testing seedlings during the packing operation and just prior to shipping. Field testing for PMS is done using the Model J-14 press, manufactured by Campbell Scientific, Inc., Logan, Utah. These measurements are taken on each seedlot prior to undercutting, after undercutting, after lifting, and as the seedlings are placed in cold storage prior to packing. This proceedure allows us to determine if mistreatment of stock resulting in increased plant moisture stress has occurred at any point in the lifting operation. We consider any PMS reading above 10 atmospheres to be indicative of problems. Using this information we can correct any systematic mistreatment of the stock and be aware of possible damage to any seedlot.

That the J-14 press provides readings exactly equivalent to those provided by the pressure bomb is not a universally accepted fact. Our quality control people who use both instruments side-by-side to test seedlings during the packing operation have consistently obtained very similar readings. A random sample of ten seedlots tested with both instruments (ten readings taken per seedlot with each instrument for each of ten seedlots) over the past two packing seasons by an assortment of individuals yielded a correlation coefficient of .88. However, midday readings taken on growing seedlings in the field during the summer of 1980 have shown that, when the pressure bomb readings have started to approach 15 atmospheres, readings with the J-14 have been significantly lower, reading about 7-9 atmospheres. Though I do not yet have enough data to draw any firm conclusions, if this relationship proves to be consistent, our use and interpretation of the J-14 press will have to be modified.

Besides monitoring the physiological condition of seedlings, every effort is made to protect them from injury during the process of lifting and transport to the storage coolers. As most lifting is done with contract labor, several contract clauses have been developed to protect the seedlings from careless mishandling. Under the contract, lifters can be fined for any of the following infractions:

1. Lifting less than two handsful.
2. Excess soil on seedling roots.
3. Abuse of seedlings to remove excess soil.
4. Failure to properly cover lifted seedlings.
5. Piling seedlings on the ground.
6. Exposing roots to the air for longer than 20 seconds.
7. Leaving any seedlings in beds.
8. Walking on seedlings.

The contract outlines specific proceedures for lifting and provides plenty of leeway for the nursery to halt operations if field or weather conditions become detrimental to the condition of the seedlings.

Lucky Peak Nursery has several inherent characteristics which inhibit quality during lifting. In addition to the limited time period when suitable lifting conditions coincide with seedling dormancy, foremost among these is the soil, which has a very high clay content. This causes excessive stripping of fine roots, a situation which has been at least partially alleviated by the use of the Egedal lifter/shaker. The fine textured soil is also very sensitive to conditions of high soil moisture, draining very slowly and becoming almost like glue when wet.

At the least this results in a slowdown of the lifting operation, frequently to the extent that dormancy is broken in the spring, accompanied by much stuck equipment and a general gnashing of teeth among all concerned. Careful planning combined with having a well-trained and resourceful field crew have helped us work around this problem. Half-track units on our lifting tractor and a crawler tractor-mounted winch have also demonstrated their value several times over.

There is sometimes a slight delay in bringing the freshly-lifted stock from the field to the storage coolers. This is caused by a particularly fast lifting crew or by field conditions which prevent the rapid loading of seedling boxes onto trailers. This is potentially a very serious problem as the seedlings may, even though they are covered by wet burlap, start to heat up, causing moisture stress. Construction of additional trailers for hauling seedlings from the field and the rental of extra tractors during the lifting season has reduced this problem. The purchase of a tractor-mounted forklift to load boxed seedlings onto the trailers in the field is expected to speed up their transportation.

Another bottleneck occasionally develops when the amount of freshly-lifted seedlings arriving at the cooler exceeds the capacity of the coolers. With the usual pressure to lift seedlings while they are dormant, it isn't possible to simply shut down the lifting until more cooler space can be made available by packing and shipping the seedlings. While many things have been attempted to alleviate this situation, including placing seedling boxes under sprinklers on the loading dock, the long-term answer is additional cooler space. Requests for funds to construct an additional cooler in fiscal year 1980 have been denied.

DISCUSSION

Quality control efforts at Lucky Peak Nursery do not begin and end with the proceedures outlined here. Plant moisture stress, shoot/root ratio, height, caliper, and dormancy tests are conducted during the packing operation. Storage temperatures are monitored continually. Indeed, every phase of our work from seed processing to shipping has some effect upon the quality of the stock we produce. We are well aware of this fact and make every effort to learn the consequences of our actions and to modify them where necessary.

Still, improvements can be made. A comprehensive study of dormancy, plant moisture stress, and the instruments used to measure them would be welcomed in order to clarify the role of these phenomena in reforestation and to reduce confusion as to their measurement. Growth chamber or root growth capacity tests of each seedlot might also be desirable. As our ability to use existing knowledge about successful seedling culture and reforestation techniques improves, and as new knowledge become available, the quality of our product will surely improve.

PUBLICATIONS CITED

Ferguson, Robert B., Russell A. Ryker, and Edward D. Ballard.
1975. Portable oscilloscope technique for detecting dormancy in nursery stock. USDA Forest Service General Technical Report INT-26, 16 P. Intermountain Forest and Range Experiment Station, Ogden, Utah.

QUALITY CONTROL

TREE PROCESSING OPERATION[1]

David W. Dutton[2]

ABSTRACT

Discusses some methods and procedures for monitoring seedling quality control during tree processing operations at U.S. Forest Service, Wind River Nursery, Carson, Washington. Describes why and how the quality training of people and good communication with the field improves stock quality and thus field survival.

INTRODUCTION

The aim of nursery stock quality controls is to provide stock which will survive, become established, and produce vigorously growing plantations.

I believe that at Wind River Nursery we have attained high quality control through the continuous training of our people in the handling and care of tree stock. This is accomplished by annual orientation and training sessions for all temporary employees.

They have responded with a dedication, interest, and hard work that is truly amazing and heart warming to see. We believe that growing quality seedlings is really not a big secret. It is the application of available and tested knowledge to a management system. It's the attention to a constant stream of daily details that many take for granted. It's the constant anticipation, vigilance and careful handling every step of the tree growing process - from the time the soils analysis is made, the seed is sown to the planting, and eventually to the survival of a high quality seedling. When you give people increased responsibliity and greater opportunities in seedling production, attention to detail comes much easier.

COMMUNICATION AND DOCUMENTATION

We stress open communication with our customers. We try to eliminate any surprises. One way to do this is through field visits to our nursery. We have been invited to most Forests to view successes as well as problems. We know these

---

1 Paper presented at Intermountain Nurseryman's Association, Western Forest Nursery Council, Boise, Idaho, August 14, 1980.

2 Assistant Nurseryman, U.S. Forest Service, Wind River Nursery, Gifford Pinchot National Forest, Carson, Washington.

visitations are successful as we now are having far fewer problems in meeting their needs. Also, we produce a stock catalog. This has helped keep everyone informed of what our seedlings look like and their average size. Every phase of our operations is governed and documented by a list of procedures. These are kept in a "Brain Book" and continuously updated.

Chairman, Dick Thatcher, has asked me to tell you about our quality control in seedling processing at Wind River Nursery. I thank him for asking us to share with you. I can best tell you in this short time by showing a few slides of some of the various steps we take. I will highlight our seedling handling from the time the trees leave the beds until they reach the requesting unit. I will now begin by introducing you to our nursery with a few general slides of the area.

LOCATION

Wind River Nursery is located in the State of Washington ten miles north of the mighty Columbia River and Bonneville Dam and about fifty miles east of Vancouver, Washington and Portland, Oregon. You may be interested in the fact we are only about 25 miles SE of the now famous and unpredictable Mt. St. Helens.

WIND RIVER NURSERY

These are overall views of our nursery fields and our landmark, known as "Bunker Hill." We have produced over 30 million seedlings annually the past seven years. This consists of about 55% Douglas-fir, 25% true firs (mainly Noble). The remainder is pines, spruces, and cedars. We sow for about 14-15 species annually.

PROCESSING FACILITY

These are views of our new Processing Facility constructed in 1977 at a cost of about 2 1/2 million dollars. We estimate this building will pay for itself in 15 years if regional seedling survival increases only 3%. This building contains three main sections: the employee wing, the main packing room, and six storage coolers with a capacity of about fifteen million seedlings. This facility was designed with our weather in mind. When the seedlings are dormant and can be lifted we lift all we can. When the weather is bad we stay inside and pack them.

Quality control in tree processing begins with our lifting priorities. They are normally as follows:

1. Cleanest lifting possible.
2. To supply field units that are ready to plant.
3. Lift the greatest number of trees at the most effective cost.
4. Lift those seedlings most likely to break dormancy earliest.
5. Lift those seedlings most likely to be in storage over three months.
6. Lift those areas last where the soils are protected from warming up due to seedbed arrangement, snow cover or shade.

SEEDLINGS LEAVING FIELD

We dedicate ourselves to getting the seedlings into cold storage as rapidly as possible, especially on days with the plant moisture stress (PMS) approaching the marginal levels. We shut down at a plant moisture stress reading of 12-15. This only occurs one or two days during the lifting season. You need to be ready and able to take action immediately.

We have found that watering the seedlings has a cooling effect and holds down the plant moisture stress.

Each seed lot is assigned a number. All seedling boxes in that lot are numbered after the box is filled with seedlings in the field. This is one of the many steps taken to assure individual lots are not mixed up and the lot qualifies to be certified at a designated level.

SEEDLINGS ARRIVING AT PROCESSING BUILDING

This series of slides is taken at our unloading area. These two coolers are designated as pre-coolers where the unpacked seedlings are stored before being processed.

TESTS

Samples for testing are taken from each lot as it arrives from the field.

LABORATORY

This is an overall view of our laboratory. Here you observe two instruments used to measure plant moisture stress in every seedlot. Our laboratory is located in close proximity to the unloading area, coolers and processing room. Size classification is taken. Also, in our laboratory the processing supervisor can examine tree quality to see if any specific grading guidelines are required.

PLANT MOISTURE STRESS TEST EQUIPMENT

We use the J-14 Pressure Jack and Pressure Bomb to measure moisture stress in our seedlings. We have also participated in the Oregon State Forest Research Laboratory Program of testing to determine the physiological soundness of seedlings prior to outplanting.

TESTING FOR DORMANCY

We have used the dormancy meter mainly in the field in fall and feel it gives us a quick indicator of approaching dormancy. We also have used the square-wave oscilloscope. Our problem is the great cost and care to keep the instrument in operation.

(What we need is Russ Ryker around to keep it running).

SHOOT-ROOT RATIO TEST

The shoot-root ratio test is a volumetric measure of water displacement of both the top and the roots. Here is a shoot-root ratio of about 1/1 on a Douglas-fir. This is an excellent ratio for Pacific Northwest planting sites.

PROCESSING ROOM

This shows the general layout of our processing and grading room. We have eight tables which were running this particular day. Our daily production is 1 million seedlings in an eight hour day.

INFORMATION BOARD

Each grading table has this board mounted on the wall with grading specifications and any special instructions. One quality control person assigned to each table is responsible for recording correct grading specifications on the board before each lot is graded. Each grader is required to read this board and thoroughly understand the "specs" before beginning work. The main requirement for a grader is to know minimum shoot and root lengths, seedling caliper and how to cull for damage. Also, the pruner needs to know pruning lengths.

GRADING AND COUNTING SEEDLINGS

This series of slides shows our overall grading and counting process. A grading table consists of twelve sorters, one buncher, one bander and a packer. Persons count seedlings in groups of five or ten. We have had requests for double sorts. We can also combine seedling species if desired. The next slide shows one of our happy nursery employees. Note the table arrangement, whereby one side faces the other. The next two slides show counting, grading and placing seedlings on a designated target line, one inch above the top lateral root. This aids in a higher quality root pruning job. This shows a watering device we can use if seedlings need washing off or appear to be drying out. One table can process an average of 130 thousand seedlings daily.

TUNNEL

A tunnel runs the length of our processing building. It is used to dispose of culls, soil, debris and excess water. Between each seed lot culls are scraped into the tunnel to avoid seed lot contamination. This definitely is a plus for quality control and seedling certification. Also, the room is kept cleaner and thus safer. When you have this condition the employees are happier and efficiency increases.

BUNCHING AND ROOT PRUNING

This person bunches the graded seedlings into bunches of 25 or 50, depending on the size. Then the seedling roots are pruned to the requested length. This is an extremely important step, because in order to eliminate contract problems the correct root length is needed.

GRADING TABLE AT BREAK

All seedling boxes are covered during break periods to prevent drying out. Also, we try not to give any seedling a total of one hour accumulated time out of cold storage. The bottom line conveyor carries the full boxes in, the top line carries empty boxes out. Empty cardboard boxes are then broken down and returned to the field. A box handler does this job for two tables.

MARKING SEEDLING BAGS

At each grading table quality control records are kept. We mark all bags with table number and lot numbers, the seed lot description, lift and pack dates and number of seedlings in the bag. When the bag is shipped, we also mark the shipping date.

BAGGING AND QUALITY CHECKS CONTROL

Each table has a leader who is also the quality control person. The quality control person checks many things according to established procedures. We need to make sure specifications are being met and we are shipping the proper number of seedlings.

BAG CLOSING

We use one sewing machine to close the bags for two tables. Our seedling bag is three layers with a waxed bottom over stitching. We try to keep bag weight under forty pounds for easier handling. Normally a bag holds about 500 Douglas-fir and 800-1,000 true fir. Good storage conditions have eliminated the need for packing media in most situations in Pacific Northwest Region nurseries.

PACKED TREES TO STORAGE

Seedlings come from the field on pallets in boxes and processed trees are stored on the same pallets. Note seedling certification tag on bag.

PACKED AND SHIPPING RECORDS

Numerous warehousing records are kept to insure we know where the trees are stored, how many were packed, how many were shipped, and when and how this was all done.

An earlier record of each seed lot information was kept on a McBee Card. Then we refined the system and now use what we call a seed lot information card. This card gives much information as to sowing, inventory and cultural practices. Another sheet which we call the silvicultural sheet originates when the order is received and is sent to the receiving party upon seedling shipment. It tells us things such as dormancy, temperatures, and humidities, and plant moisture stress, equipment used, time and day lifted. It can also give any special instructions. This helps us adjust operations accordingly. This sheet also has a section that the field can fill out upon receiving the trees. This record has helped us often identifying why a particular problem occured and in other communications with our customers.

TREE STORAGE AND MECHANICAL ROOM

Temperatures and humidities are constantly monitored and documented to avoid any large fluctuations in the storage rooms. Fluctuations are only about one degree for temperature and 5% for relative humidity. I feel that our excellent cold storage facilities are a big factor in our increased survival.

SHIPPING

The seedlings are taken out of storage and loaded into a truck. Note the large loading dock and person checking the seed lot and numbers being loaded. We try to schedule most deliveries so that delivery is made in one day. Temperatures are monitored by thermographs placed among the bags. Our people are instructed to handle the bags as if they were eggs.

DELIVERY

Presently we deliver about 20 million seedlings or 2/3 of of annual production to our customers in Oregon and Washington. All Forest Service seedlings are shipped in refrigerated vans. With our present mileage restrictions we are being forced to seek other means to deliver our seedlings.

SEEDLING CERTIFICATION

Every step of our seedling processing is also monitored by our seed certification agency, which operates both in Oregon and Washington.

CONCLUSION

Now if St. Helens cooperates and doesn't cover us with a foot of ash we hope to continue producing quality seedlings for the Pacific Northwest Region. We invite you to visit us.

In conlusion, I say to you that we can afford to take most every precaution in seedling care and handling that is known. All costs are continuously going up and we can't afford to plant a low quality seedling. I believe the "proof is in the puddin'."

Our Region's field survival has increased dramatically. The key to this increase is management's ability to provide us with equipment and facilities. Another key is communication and documentation for our customers, the Ranger District people. Last, but not least, is our ability to handle seedlings in such a manner that vigor is not diminished. All this is accomplished through procedures and communication with our own people.

PUBLICATIONS CITED

Van den Driessche, R.
1976. Quality control of nursery stock. Paper presented at B.C. Reforestation Board Meeting. pp. 1-9.

Chavasse, C.G.R.
1979. Pitfalls in field evaluation of planting stock. Unpublished paper presented at the IUFRO reforestation workshop in New Zealand. 18 pp.

REQUIREMENTS FOR QUALITY IRRIGATION[1]

Marvin N. Shearer[2]

ABSTRACT

Quality irrigation requires that irrigations be applied at the right time, at the right rate, in the right amount and uniformly. Uniform application and appropriate application rates are obtained through the proper selection of nozzle diameter, sprinkler spacing, and pressure.

INTRODUCTION

Budgets and competitive bidding, rather than quality performance, dominates the design of sprinkler systems today. But that small amount of money saved is dwarfed many times as losses pile up on losses year after year from the effects of less than adequate design.

Some words in our vocabulary tend to become useful primarily for their value as rhetoric for they have the ability to charm and influence. "Efficiency" is one of these; "quality" is another. Unless we give definition to these words, they can have all kinds of meanings, or none at all.

Let me tell you what I mean by quality irrigation. It is irrigation that occurs at the right time, it is applied in the right amount, it is applied at a rate so that the water penetrates into the soil rather than ponding on the surface or running off, <u>and</u> it is applied uniformly.

Recognition of the importance of uniform water distribution and procedures for obtaining it are two of the most prominent omissions in sprinkler system design and procurement, and this is the first subject I wish to talk about today.

UNIFORM WATER APPLICATION

Application Efficiency

We can achieve high application efficiency and at the same time do a totally unacceptable job of irrigation. Let me illustrate.

---

[1] Paper presented at Joint Meeting, Intermountain Nurseryman's Association and Western Forest Nursery Council, Boise, Idaho, August 12, 13 & 14, 1980.

[2] Marvin N. Shearer is Extension Irrigation Specialist and Professor of Agricultural Engineering, Oregon State University, Corvallis, Oregon.

Application Efficiency = Average depth of water infiltrated and stored ÷ Average depth of water applied.

In Figure 1 we observe an irrigation requirement of one inch of water (the amount required to bring the soil to field capacity in this case). We turn the system off before any area receives more than one inch of water so that all water infiltrating the soil is stored. From five to ten percent of the water leaving the sprinkler may be lost by evaporation. Since there are no runoff or percolation losses, the application efficiency may be 90 to 95% with 100% of the water reaching the soil being stored there. Some areas, however, will be greatly underirrigated.

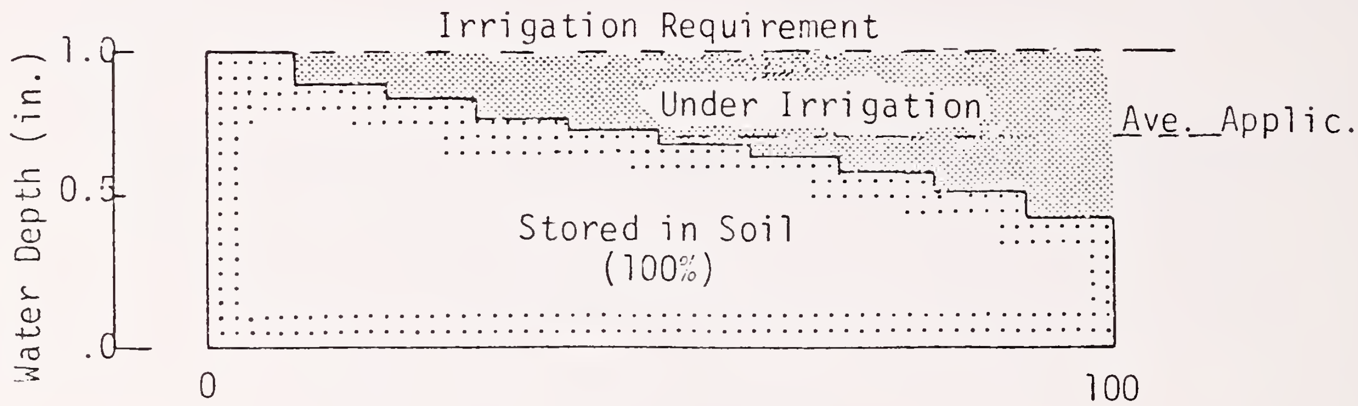


Figure 1.--Example of water distribution at 80% uniformity coefficient with severe under-irrigation.

The effect of extensive under-irrigation can be reduced by increasing the average amount applied and over-irrigating, as shown in Figure 2.

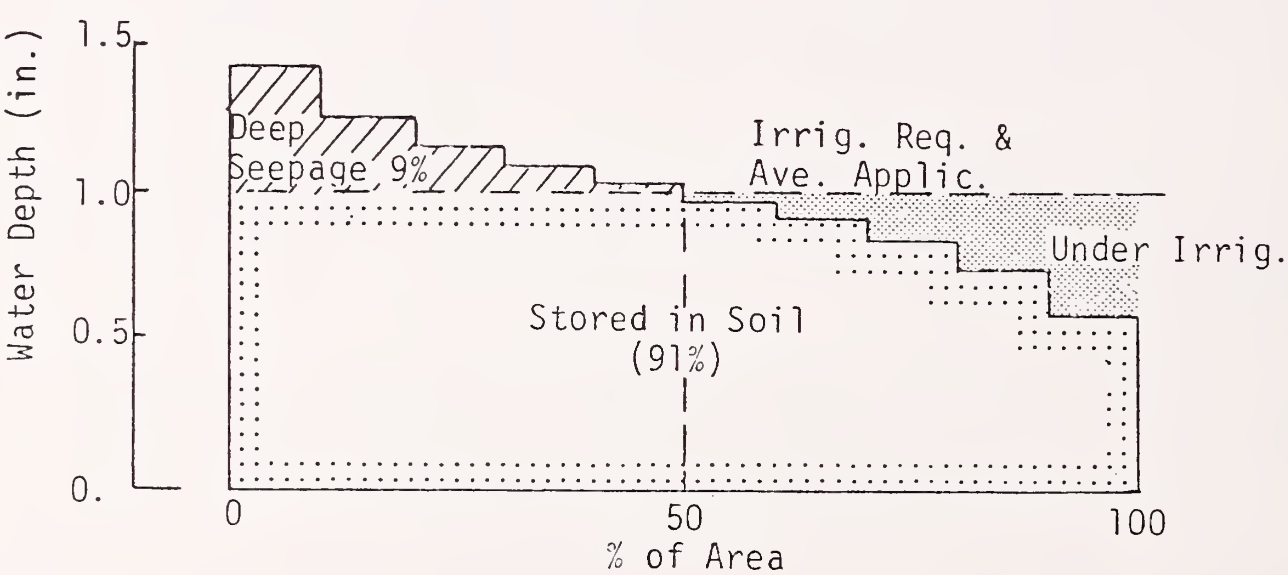


Figure 2.--Water distribution at 80% uniformity coefficient and 50% adequacy of irrigation.

Here we have the same uneveness in water distribution, but we have reduced the amount of under-irrigation 50% in some areas by over-irrigating an equal amount in other areas. Under conditions of good internal soil drainage this may not be too bad, but chances are for young tender plants, 20% of the area in this situation could have damaged plants due to lack of adequate water.

Adequacy of Irrigation

Under-irrigation can be reduced even more by increasing the average amount applied, as shown in Figure 3. Notice what has happened to the seepage loss. It has increased from 9% to 21% of the water reaching and infiltrating the soil. We would say in this example that we had achieved an adequacy of irrigation of 75%, which means that 75% of the area irrigated received the irrigation requirement or more, and 25% received the irrigation requirement or less.

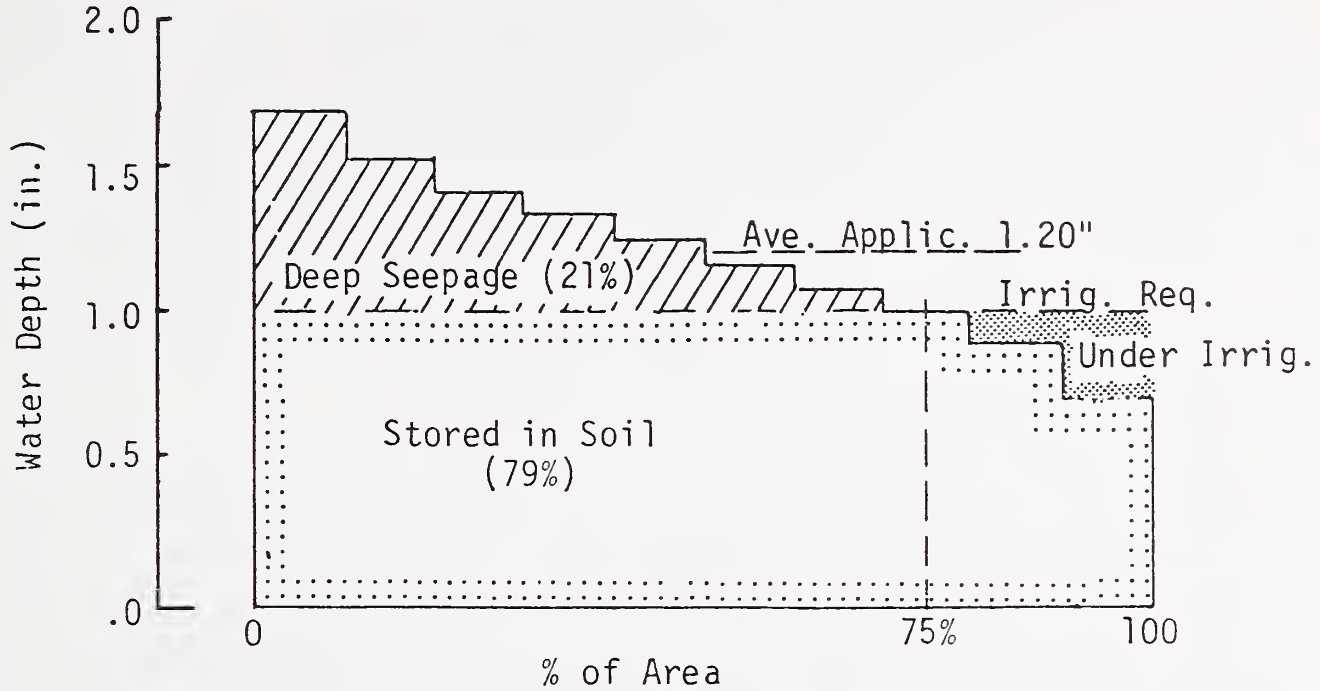


Figure 3.--Water distribution at 80% uniformity coefficient and 75% adequacy of irrigation.

Uniformity Coefficient

How uniformly water is applied to soil is described by a statistically derived number called a uniformity coefficient. In Figure 4 you see distributions for three uniformity coefficient values. Departure of depths of water applied from average application gives an indication of the extent of over- or under-irrigation. The question that must be answered by the nurseryman is: How much is he willing to pay for uniform distribution?

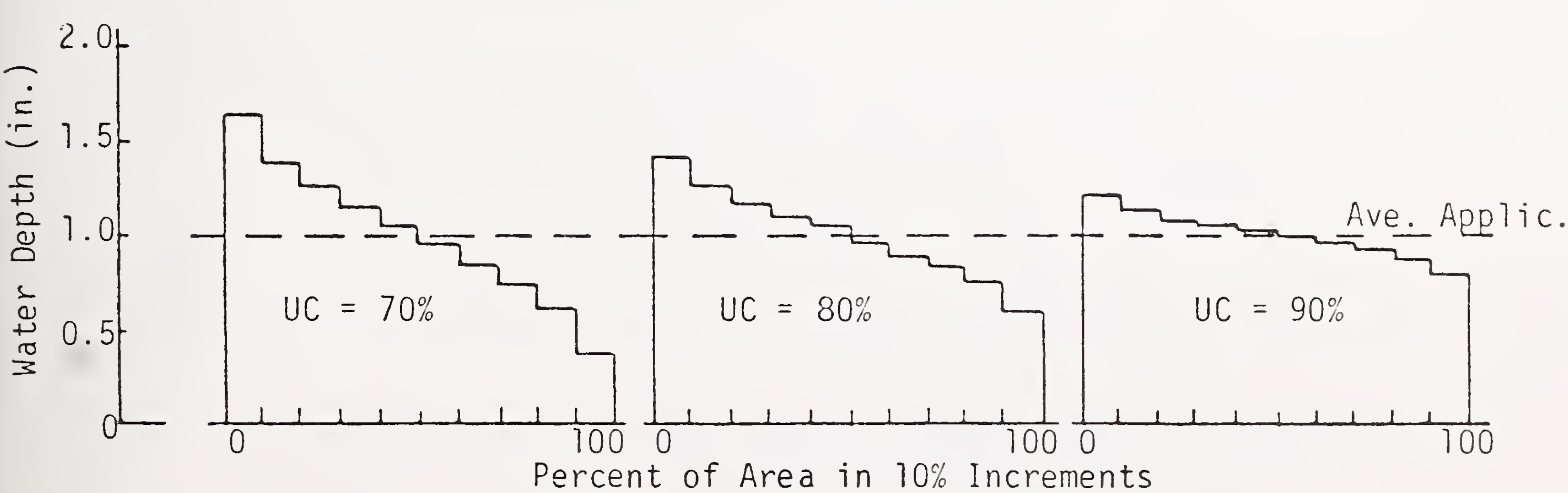


Figure 4.--Water distribution for three uniformity coefficient values.

I suggest that for high value crops having small root systems, such as nursery stock, the minimum acceptable value should be 85%. For high value crops with extensive root systems, such as full-grown trees, possibly 70% uniformity coefficient is acceptable. Plants with smaller root systems require higher uniformity coefficients since the root systems are unable to extend from areas of low water applications to areas of abundant applications. The extent of over- or under-irrigation is controlled by the adequacy of irrigation as described earlier.

ACHIEVING UNIFORM WATER APPLICATION

Uniform water application is achieved by selecting the correct combination of nozzle size, sprinkler pressure, and sprinkler spacing for the wind conditions which exist during irrigation. A number of sprinkler manufacturers have the capability of testing sprinklers to determine the performance characteristics of their sprinklers. But, very little of this information is distributed for public consumption. I am sure that if in our purchases, we specified uniformity levels that must be achieved after system installation, we would see a marked improvement in the performance of solid set sprinkler systems being installed in the field today.

Sprinkler systems that distribute water evenly cost more money than systems that don't, because they require more sprinklers, more pipe and more fittings. A purchaser must be willing to pay for a quality performing system. No supplier can bid a quality performing system without a corresponding increase in price.

Solid set sprinkler systems as they are generally sold, usually do not apply water as uniformly as side move or hand move systems. In an effort to reduce costs, sprinklers are spaced too far apart. They may be able to apply water in a somewhat satisfactory manner in winds of 0-5 mph, but when winds increase beyond this point water distribution falls off very rapidly.

Studies to determine the relationships between sprinkler application profiles, sprinkler spacing and eveness of water distribution were conducted as early as the 1930's. More recently studies of techniques used to predict uniformity of distribution under various wind conditions from sprinkler profiles obtained under no-wind conditions have been made. Unfortunately, this information is not readily available for all sprinklers or from all sprinkler manufacturers.

SPRINKLER SPACING RECOMMENDATIONS

A number of theoretical sprinkler profiles were studied by Christensen in 1942, and from these studies general conclusions were drawn which are still valid today. They don't take the place of specific data for specific sprinklers, but they are quite helpful when such information is not available - which is most of the time.

In general, his studies showed that when sprinklers are operated in winds of 0-5 mph and are spaced in a rectangular pattern, the maximum spacing in one direction should be 60% of the no-wind diameter and the sum of the two spacings 105% of the diameter.

In winds from 5 to 10 mph, maximum spacing should be 50-55% of the diameter and the sum of the two spacings 85% of the diameter.

There is usually no real advantage in using triangular spacings unless extended spacings are used. Extended spacings are 65% or more of the no-wind diameters. Such spacings prove disastrous though if even slight winds develop. The results of these extended spacings are apparent in many nurseries.

Continuously moving laterals provide the best uniformity because sprinklers are infinitely close in the direction of the lateral move and can be spaced quite closely along the lateral. Unfortunately, these are not particularly adapted to nursery conditions because they lack the flexibility required under nursery irrigation programs. In addition, they cannot be used successfully for frost protection.

During the last few years there have been straightening veins added to impact sprinklers for the purpose or straightening the flow through the sprinkler and increasing the area covered by the sprinkler pattern. Unfortunately, another characteristic accompanied the increased diameter; a change in the sprinkler profile resulting in a deficit of water about one-third the way out from the sprinkler. In order to compensate for this, it has been necessary to increase pressure at the sprinkler by 5 to 15 pounds per square inch or to add a secondary small nozzle to fill in the area not covered by the range nozzle. There is nothing wrong with small nozzles except they plug easily when surface water is used.

RATE OF APPLICATION

A second factor affecting irrigation quality I wish to discuss briefly is rate of application.

In Oregon, Oregon State University has been involved in a cooperative program with the Soil Conservation Service to test intake rates of soil under sprinkler irrigation. We have used a portable water tank and a special designed sprinkler arrangement which allows us to apply a wide variety of rates over a small area. Through visual observation and catch measurements of replicated sites we have developed "best estimates" of soil intake rate for use in sprinkler system design. These values are available in Soil Conservation Service Irrigation Guides.

If on your nursery you notice water ponding on the surface, or running off plots, you are applying water too fast. Lower application rates are achieved with smaller sprinklers and appropriate closer spacing. It is not accomplished simply by extending spacings of existing sprinklers as such action will result in lowered distribution uniformity.

Proper scheduling of irrigations, both time and amount, is also essential for quality irrigation. However, time has not permitted me to discuss techniques of achieving appropriate scheduling today.

SUMMARY

Uniform distribution of water is essential for quality irrigation. It is achieved through appropriate selections of sprinklers, sprinkler pressure, and nozzle diameters. Such selection will provide appropriate application rates.

PUBLICATIONS CITED

Christiansen, J. E.
1942. Irrigation by Sprinkling. California Agricultural Experiment Station. Bulletin No. 670.

Hart, W.E. and Reynolds, W.N.
1964. Analytical Design of Sprinkler Systems. American Society of Agricultural Engineers, Fort Collins, Colo. Paper No. 64-201.

Hart, W.E., and Hermann, D.F.
1978. Evaluating Water Distributions of Sprinkler Irrigation Systems, Colorado State University Experiment Station, Fort Collins, Colo. Tech. Bul. 128 (revised).

Keller, J., Moynahan, M.D., & Ptacek, R.L.
1971. Sprinkler Profile Analysis to Predict Field Performance. American Society of Agricultural Engineers, Chicago, Ill. Paper No. 71-756.

Shearer, M. N.
1970. Comparative Efficiency of Irrigation Systems, Proceedings - Irrigation Association Technical Conference, Cincinnati, Oh.

FIELD HANDLING [1/]

Glenn Jacobsen [2/]

ABSTRACT

A field handling system for care of seedlings from the nursery to the planting hole has been implemented in the Intermountain Region of the Forest Service. This system has improved both survival and growth of the seedlings.

INTRODUCTION

Dick Thatcher asked Al Dahlgreen and me to explain how we handle seedlings from the nursery cooler to the planting site and our planting procedure. I will cover the field handling procedure and quality control in the Intermountain Region of the U. S. Forest Service and the Payette National Forest. Al will then cover planting the seedlings, inspection for quality, and results of our reforestation efforts.

Tree seedlings that are properly cared for during lifting, packing, storage, and field handling demonstrate a great desire to survive and grow when outplanted. Seedlings are living organisms subject to environmental factors. They can cope with these factors in a suitable environment, but are extremely vulnerable to physiological as well as mechanical injury when out of the ground. Seedlings are exposed to many causes of injury from the time of lifting until outplanted. Survival and growth responses are influenced by the number, degree, and duration of such injuries, in addition to the site and other factors. These damaging effects are cumulative and are often interacting.

A field handling system for care of seedlings from the nursery to the planting hole has been implemented in the Intermountain Region of the Forest Service. Reforestation personnel on the Payette National Forest have been following this system since the early 1970's.

Our main objective in artificial reforestation is good survival and growth of seedlings to obtain a satisfactorily stocked, rapidly growing stand. To achieve this objective, proper handling of stock from the nursery to the planting site is necessary. Our goals for handling stock are:

1. Minimize disturbance of seedlings.

2. Minimize variation from optimum temperature and relative humidity levels.

3. Minimize moisture stress, exposure, and mechanical injury.

1/ Paper presented at joint meeting of Western Forestry Nursery Council and Intermountain Nurseryman's Association, Boise, Idaho, August 14, 1980.
2/ Forest Silviculturist, Payette National Forest, McCall, Idaho.

4. Provide for gradual transition of seedlings from storage to field conditions.

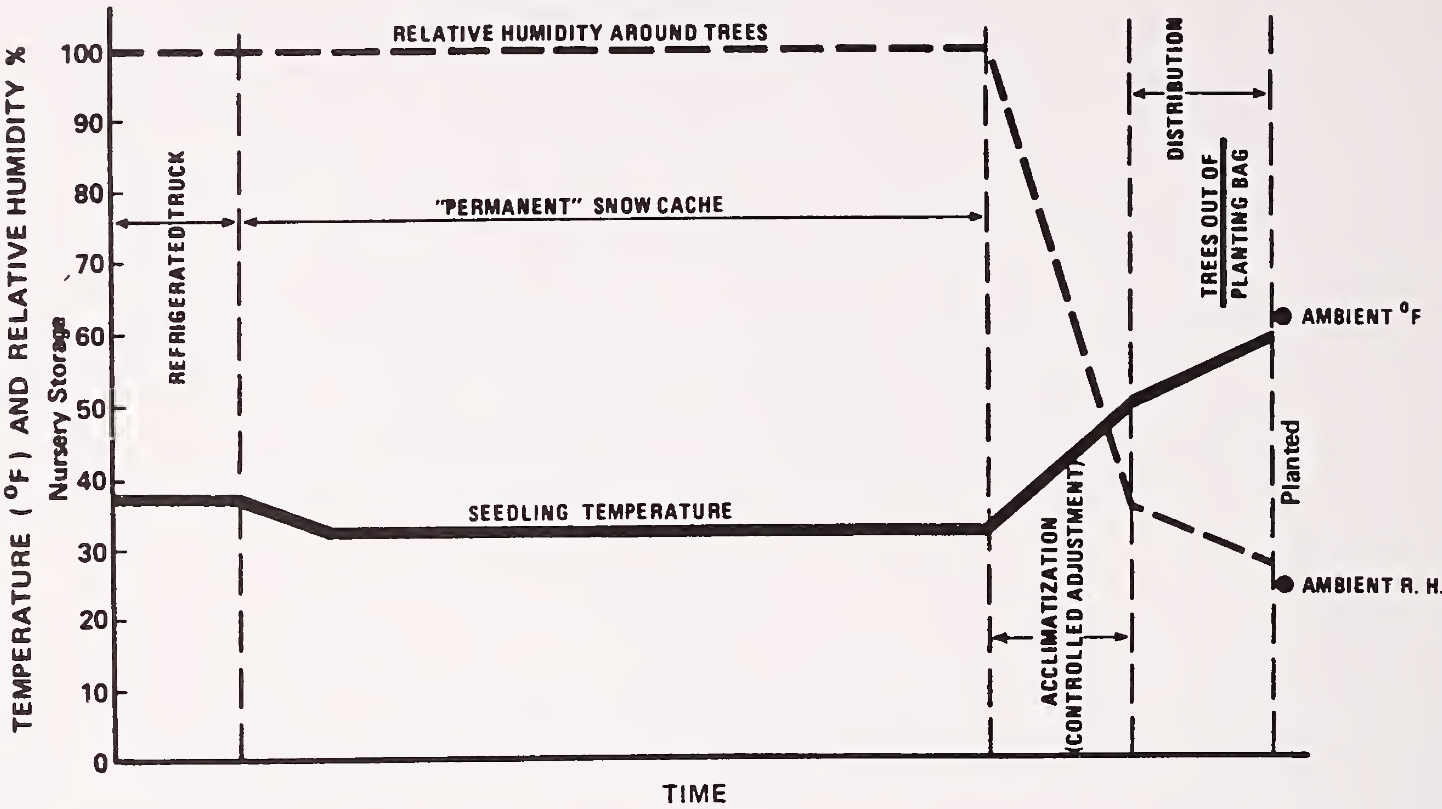


Diagram of temperature - relative humidity regimen considered ideal for seedlings during the nursery to planting hole journey in the Intermountain Region. The objective is to reduce the frequency and rate of environmental change which could injur the seedlings. (Time frame not to scale).

We obtain nursery stock from both Lucky Peak and Coeur d'Alene nurseries. Seedlings are generally lifted, sorted, and packed the end of February or the first part of March. During this time the District people are plowing snow to open roads to their snow cache locations for seedling storage.

LOADING

Bare root stock stored in nursery coolers is loaded on refrigerated trucks for delivery to the Forests. Racks are built in each truck to allow stacking of the crates without crushing, yet still leave adequate air space between crates to allow air circulation and prevent temperature increases. Seedlings are loaded by seed lot for each snow cache location. Trees are generally loaded the evening before delivery with the refrigeration units left in operation. The objective is to maintain a root mass temperature of no higher than 36° - 38° F. This is about the temperature we can currently expect seedlings to come out of the nursery coolers.

DELIVERY

Delivery occurs during the second or third week of March on the Payette National Forest. When possible, delivery is coordinated between Lucky Peak and Coeur d'Alene nurseries for the same day. Lucky Peak trucks generally arrive at the delivery points

at 0800. The trucks are driven directly to three of the four snow cache locations on the Forest. Due to a muddy, steep road on the Weiser Ranger District, seedlings are unloaded into a stake rack truck in a shaded location, covered with a tarp, and delivered to the snow cache. Thermometers are placed inside the refrigerated trucks to record root mass temperature upon delivery. The temperature readings are recorded on the delivery ticket for a permanent record. We document these conditions for evaluations of our plantations.

STORAGE

A day or two prior to tree delivery, each District prepares a packed snow floor for their snow cache. Minimum depth of the snow floor is two feet. This is necessary to prevent seedlings touching the ground if the snow melts.

We are faced with a storage period of two weeks to four months depending on elevations and aspects of planting sites. Sites are located at elevations of 4,000 to 6,500 feet above sea level. Planting begins at the lower elevations about the third week in April and may last until the third week of July at the high elevation spruce sites. The bulk of our planting is done in May.

Due to the length of storage, up to 120 days, we use a snow cache. Snow caches provide an environment of uniform high humidities and a constant temperature of 33° F. This appears to be ideal for seedling storage. As with any job, there are proper procedures to be followed to prepare a snow cache.

When a refrigerated truck delivers seedlings to a snow cache, extreme care is taken when unloading seedlings to prevent damage to the buds, especially ponderosa and lodgepole pine. Seedlings are packed in lettuce crates specifically for snow cache storage as trees are least susceptible to damage in a crate. Boxes or bags may be crushed when snow is piled on them.

Crates are stacked in an orderly manner with boards between the third and fourth crates. This helps in removal of crates. Root mass temperatures and ambient humidities have been monitored inside the cache. A properly constructed snow cache will maintain a temperature of 33° F. and a relative humidity of 100%. Stacks of crates have air spaces between them and rows are spaced one to two feet apart. Snow is shoveled between the stacks and the rows until there is enough snow covering the crates to utilize a tractor to pile four feet or more of snow over the trees. A sawdust layer of up to one foot deep is then placed over the snow for insulation, plus a canvas on top of the sawdust. Canvas helps reduce snow melt. A map showing seed lot location is prepared to assist with proper removal of the trees. It is generally less than two hours from the time of unloading the trees until they are covered by snow.

The cache is generally not opened until two days before tree planting begins. Extreme care is taken to remove only the minimum amount of snow needed to create an opening to the row of trees which will be planted first. The opening is then closed with insulating material when not is use in order to retard snow melt and maintain existing temperature and humidity inside the cache.

ACCLIMATIZATION

Trees are prepared for acclimatization and field distribution by dipping their roots in a vermiculite and water slurry and rolling them in wet burlap. Water held by the vermiculite is readily available to replace any the trees may have lost in storage,

as well as that which will be transpired prior to planting. The wet vermiculite particles help reduce root stripping by acting as a lubricant; they maintain a film of moisture on the roots during the brief journey from planting bag to planting hole, and they aid planting inspections by "marking" seedling roots.

The burlap protects the tree roots from mechanical injury or exposure, assures good root contact with moist material, and binds the seedlings in a safe and convenient package for field transportation and distribution. The entire procedure has a beneficial psychological value, reminding all concerned of the need for extreme care in handling trees.

A shaded tent is used for packaging trees. It is large enough to accommodate a two-day supply of trees, a work table, two large garbage cans, and one or two tree handlers. It may be located near the snow cache, or at the planting area. Trees are transported from the cache to the dipping and wrapping area in an insulated pickup box or a tree trailer on an "as needed" basis. Trees are removed from snow cache in early morning or late evening and moved to the acclimatization facility in a tree trailer. A one- or two-day supply is removed at each entry if the usual 24-hour acclimatization period is used. Number 4 horticultural vermiculite is mixed into a large garbage can of water to make a thick slurry and allowed to soak until well saturated. A second garbage can is used to soak 20-inch by 30-inch pieces of burlap which have been impregnated with mud to improve water retention.

A piece of the wet burlap is spread on the table and a handful of seedlings is removed from the shipping container. Roots of trees remaining in the container are kept covered. The trees are grasped with both hands so their roots tend to spread. The roots are then dipped into the slurry and gently agitated until thoroughly coated with wet vermiculite when removed. The slurry is kept stirred, since wet vermiculite sinks. The seedlings are gently separated and arranged in an orderly manner on the burlap with roots parallel to the short axis, and root collars about one inch below the upper edge of the burlap. Additional seedlings are similarly treated until the desired number (usually 50 to 100, depending on tree size and weather conditions) are in place. Roots may be trimmed so they are within specifications--(12 inches).

The exposed flap of burlap is folded over the roots, care being taken not to bind any roots in the fold. The burlap, with trees in it, is firmly rolled from one end to the other, jellyroll fashion. The outer end of the burlap is pinned or tied in place. The resulting package must be firm so trees have good root contact with the wet material and will not fall out. Proper placement of trees on the burlap and correct rolling facilitates removal of the trees with minimum root stripping.

Acclimatization is completed in the packaging tent, or in a snow-free tree trailer. Trees can be more gradually brought into equilibrium with an environment near that which prevails on the planting site, if temperatures and humidities surrounding the trees are monitored occasionally at different points in the handling process. Procedures can then be changed to soften any stressful conditions noted.

The packages of trees are stacked in single rows on low platforms of lumber or poles. The burlap-covered roots are aligned vertically and horizontally within the stack, with tops alternating from side to side to permit free air circulation around them. Stacks are no more than five or six packages high, and tops of trees in adjacent rows are at least one foot apart.

Newly packaged seedlings should be covered with light canvas or other material which is removed as the trees approach equilibrium with the surrounding environment. Doors of tree trailers are adjusted to achieve similar control.

Trees should be protected from freezing by covering with insulating blankets or holding them at the desired temperature in insulated trailers. Protective coverings are removed, or tree trailer doors reopened, when freezing conditions no longer prevail.

Longer acclimatization periods (up to 48 hours) are required during warm, dry weather than on cool, humid days. Seedling temperatures should be near the soil temperature at a depth of 8-10 inches, or air temperature, whichever is lower, at the time of planting. Humidities around their tops should approximate that found in the shade near the ground on the planting site.

DISTRIBUTION

Trees are brought from equilibrium with the environment at the acclimatization site to equilibrium with that of the planting site during the distribution process. They should suffer little stress if differences in temperature and humidity between the two sites are not great and the transition is not rapid.

Trees are issued for planting in the same order they were packaged. They are not placed in or on snow or ice, nor are their tops covered by wet burlap or other material (except as protection from freezing) after acclimatization has started. Such "protection" nullifies the benefits of acclimatization.

Trees are kept in the shade and protected from the wind while being transported or held at the planting site. A pickup truck with a cover may be closed while moving and opened when stopped to provide ventilation when parked. Wet burlap placed over the root zone (not on the foliage) of stacked trees will slow drying of the top layer of tree packages.

Trees are placed in clean planting bags. The nail or string holding the tree packages together is removed <u>after</u> the trees are in the bag or tray, but <u>before</u> trees are removed. We use planting bags 18 inches deep, generally of white canvas with a shield of waterproof material on one side to protect the planter from water seepage.

In addition, inspections and documentation of care of the planting stock are done on a daily basis.

EVALUATION

Thermometers are standard equipment for reforestation personnel. They are used frequently during the storage and handling of seedlings to monitor temperatures. We also request assistance from Russ Ryker, silviculture researcher from Intermountain Forest and Range Experiment Station, to use an oscilloscope or other techniques to monitor seedling condition if something looks strange to us.

PUBLICATIONS CITED

Dahlgreen, Allen K.
1976. Care of Forest Seedlings from Nursery to Planting Hole. Paper presented at Tree Planting in the Inland Northwest Conference held in February 1976 at Washington State University, Pullman, WA.

Dahlgreen, Allen K., Russell A. Ryker, and David L. Johnson.
1974. Snow Cache Seedling Storage: Successful Systems. USDA For. Serv. Tech. Rep. INT-17, 12 p. Int. Mt. For. and Range Exp. Stn., Ogden, UT.

FIELD HANDLING AND PLANTING

PLANTING

Allen K. Dahlgreen [1/]

ABSTRACT

A program was initiated in the USDA Forest Service Intermountain Region in 1968 which significantly improved performance of forest tree plantations on National Forest lands within the Region. A substantial part of this improvement can be attributed to the application of quality control procedures to the field planting operations.

INTRODUCTION

I am sure you wonder why discussions of field handling and planting of forest tree seedlings have been included in your agenda.

Our purpose is to extend and increase your concern for quality reforestation beyond the nursery gate and through the field storage, handling, and planting process. To do this we will point out the need for a high level of quality control in outplanting operations, and describe some handling, planting, and quality control techniques which have proven effective in the Intermountain Region of the U.S. Forest Service. We hope to thereby encourage you to become involved in the reforestation efforts of those who use your seedlings - visiting ongoing and past projects, making observations, asking questions, offering suggestions, and monitoring performance. The goal is better survival and growth, and greater satisfaction for all concerned.

Those who purchase or use the seedlings you produce expect and deserve good survival and growth from those trees. Poor plantation performance, regardless of cause, reflects adversely on your facility and degrades the image of artifical reforestation in general. It is costly in terms of monetary and resource values.

However, the very best trees, grown, packaged, and stored under strict controls, will not perform properly if planted "offsite" or subjected to improper field handling and planting procedures. The need for quality control does not cease when the trees leave the nursery--it becomes more acute.

Seedlings in the nursery are under intensive care. They are tended, for the most part, by a small group of skilled technicians and professionals whose primary concern, yearlong, is the well-being of the trees.

On the other hand, the skill levels and concerns of those who handle and plant the trees in the field vary greatly. Some are aware of and apply excellent field

1/ U. S. Forest Service, Retired, Leavenworth, Washington, 98826

storage, handling, and planting procedures. Others want to do the job right--but don't know how--and fail to ask someone who does. And some consider tree planting a futile, unpleasant task to be disposed of as quickly as possible. In any event, problems develop on even the best organized projects. People develop bad habits as work progresses; they become tired, erroneous beliefs surface and are applied, important details are overlooked in the rush to get the job done, and equipment malfunctions occur. Murphy's Law never fails!

These are but a few of the general situations I have repeatedly encountered in 20 years of intensive involvement with forest tree planting. I mention them to emphasize the need for effective quality control after the trees leave the nursery. Some of you have had similar experiences.

THE INTERMOUNTAIN REGION, U.S. FOREST SERVICE EXPERIENCE

The U.S. Forest Service Intermountain Region experienced good survival and growth of planted ponderosa pine (*Pinus ponderosa* Laws.) seedlings through the late 1950's and early 1960's. Most of this was early season (low elevation) machine planting on machine terraced, stripped, or furrowed sites. Plantation performance declined as work progressed to more difficult terrain and higher elevations. It became necessary to depend on hand tools for site preparation and planting; seedling storage periods increased from weeks to months; seed source, species, and site coordination became more difficult. [1/] Hot, dry weather during planting became common as planting seasons extended into the summer. The limited data available indicates that Regional average first-year survival had slumped to 65 percent or less in the 1966-1969 period.

A program to improve plantation performance was started in 1968. This included betterment of conditions and operations at Lucky Peak Nursery as well as improvement of field storage, tree handling, and planting procedures.

The following is a tabulation of the Regional average first-year plantation survival as summarized from reports of each National Forest in the Region for each year since 1971 (U.S. Forest Service, 1979):

Year	Percent Survival
1971	70
1972	75
1973	88
1974	88
1975	86
1976	83
1977	89
1978	80
1979	73

These data represent, with few exceptions, survival determined from individually staked trees on about 90% of the acreage planted each year. The depressed survival in 1979 may be attributed, at least in part, to weather conditions. Data from many weather stations show that 1979 was the driest year on record for 40 years or more (U.S. Forest Service, 1979) over much of the Region. Fire weather conditions were the worst in the history of the Region (U.S. Forest Service, 1980).

1/ Species commonly planted include ponderosa pine (*Pinus ponderosa* Laws.), lodgepole pine (*Pinus contorta* Dougl.), Rocky Mtn. Douglas-fir (*Pseudotsuga menziesii* var. *glauca* (Beissn) Franco.), Engelmann spruce (*Picea engelmannii* Parry.), blue spruce (*Picea pungens* Englem.), and western larch (*Larix occidentalis* Nutt.).

The "Wyoming Utilization Study" (Lotan and Perry, 1977), (Schmidt and Lotan, 1980), was initiated in 1971 on the Bridger-Teton National Forest in western Wyoming. The study area was at an elevation of about 9,300 feet (2,850 m) above sea level. Trees planted in 1973 in the reforestation phase of the study demonstrate the results obtainable when trees from the proper seed source are properly stored, handled, planted, and protected:

> Only seven of the 1,560 staked 2-0 lodgepole pine sample trees died the first season after planting. Initial survival for all harvest/fuel treatment methods was thus over 99.55 percent.
>
> Fifth-year survival on the broadcast burned and tractor piled and burned fuel treatments was over 87 percent. Average height of these trees was over 45 centimeters; some trees were over 90 centimeters tall.

The performance achieved cannot be attributed solely to the tree handling and planting procedures used. Work by Research Foresters Russell A. Ryker and Raymond J. Boyd of the USDA Forest Service Intermountain Forest and Range Experiment Station, former Lucky Peak Nurseryman Frank E. Morby, and more recently your host, Richard H. Thatcher, were essential to these successes.

Glenn Jacobsen has already discussed the field storage and handling procedures which we found essential to success. I will now try to explain what we consider good planting quality and how we obtained it in the Intermountain Region. Many of these ideas and procedures have been around for decades, people just weren't using them. Others developed as work progressed. The program benefitted from the inputs of many technicians and foresters, and several USDA Forest Service Contracting Officers! We hope you and others may find this information useful.

THE BASIS FOR QUALITY TREE PLANTING

Quality control involves more than conducting inspections to determine whether certain tasks have been done to specifications. It must be designed into the project in the form of tools and procedures that simplify the work, are relatively easy for the workers to use, and which minimize the probability that things will be done incorrectly. Training must be appropriate and adequate at all levels. Skilled supervision/contract administration must be provided. Finally, inspectors must be thorough, fair, and work closely behind planting crews. Subsequent followup on plantation performance provides data on overall program success, and often helps identify procedures that need improvement.

The biological and physical needs of the trees, insofar as we were aware of them, dictated the planting standards which evolved. The eleven inspection elements commonly recognized, and a synopsis of standards applicable to each, are as follows (for the full standard, please see the USDA Forest Service "Westwide" Tree Planting Contract developed in 1978.):

1. Tree spacing - prescribed to fit site requirements; limited variation permitted.

2. Planting spot selection - where local features provide best protection from hazards.

3. Site preparation - at least 24" x 24" to mineral soil, configuration as specified.

4. Tree location on spot - near center of site-prepared spot if applicable, no less than 9" from live vegetation.

5. Planting depth - soil shall be even with original ground line of trees; no roots exposed; no branches or needles covered.

6. Stem position - at an angle between perpendicular to the slope and true vertical.

7. Planting hole orientation - same as stem position.

8. Root configuration and orientation - roots aligned along the axis of the planting hole, extending downward in a near natural arrangement; not doubled, spiraled, bunched, or bent.

9. Root damage - roots shall not be shortened, pulled, stripped, crushed, or abraded.

10. "Foreign" material in the hole - moist mineral soil only around the tree roots. Dry soil, ash, organic matter, rock, and other material shall be kept out of the holes.

11. Soil firmness around roots - soil shall be filled in and firmed progressively so no loose soil or air pockets remain, and tree is as firmly planted as soil conditions allow.

Certain procedural requirements must also be adhered to. Some of these are listed here:

1. Snow or ice must be kept off of trees that have been acclimatized.

2. Trees must be kept in a shaded location, out of the wind when not being carried by a person actively engaged in planting. This applies during rest and lunch breaks as well as in stockpiles.

3. Trees must not be exposed to the fumes of petroleum products or other harmful substances.

4. Trees shall be gently removed, one at a time, from the planting bag or tray, and quickly and gently inserted in the planting hole.

5. "Slit" planting will not be permitted. Planting holes must be "broken out on three sides" or drilled with a 4" diameter auger capable of making a hole 14" deep. (Tree roots are 12" long.)

6. Planting holes must be filled and firmed by hand only. Sticks, trowels, and other tools must not be used to fill or firm the soil. The soil may not be firmed with the boot heel.

PLANTING METHODS

Planting machines best meet the criteria mentioned earlier for promoting quality planting. They are simple and easy to operate once they have been attached to the tractor and essential adjustments properly made. Few people are involved, and operators need not learn difficult or complex procedures, even on the nonautomatic machines, which

are best for stoney ground. Additional firming of soil around the tree roots may be necessary on heavy soils. However, this is seldom a problem, and an extremely high percentage of properly planted trees can be obtained on machine planting projects.

A variety of planting hoes, planting bars, dibbles, modified tile spades, and shovels have been used for tree planting. These tools require considerable skill and physical strength of the user. In addition, many people must be trained to properly select (and often site prepare) planting spots, drive the tools into the ground, open the planting hole, insert the tree (often into a tangle of roots), make sure the tree roots are straight, and close the hole so the soil is in firm contact with the tree roots. Proper planting by these methods is quite complex and is physically difficult for many people. There are a great many opportunities for error since each planter is repeatedly faced with a variety of problems and obstacles to good planting. Very close supervision/contract administration and inspection procedures must be exercised to maintain planting quality in most situations where these tools are used.

Powered soil augers meet the criteria for promoting quality planting. Although this method is not nearly as automated as machine planting, it is applicable to a much wider range of soil and terrain conditions. Auger planting has an advantage over machine planting in that it does not create artifical burrows which may promote gopher damage. The use of soil augers breaks the planting operation into two components: hole making and planting.

The auger operators select the planting spot (unless already selected by the "scalping" crew) and drill the planting hole to the proper depth at the correct angle. The auger excavates the soil and small rocks, cuts small roots, and pushes larger rocks aside, depending on soil conditions. The result is a clean four-inch diameter hole to the proper depth. The excavated soil is neatly deposited around the hole. Well coordinated people with reasonable strength are easily trained to be good auger operators.

The planters have a fairly uniform situation at every planting spot: a clean planting hole to specifications with a supply of replacement soil close at hand. They need only pull aside the small amount of loose soil in the bottom of the hole, insert the tree to the proper depth (straightening its roots as they do so), and progressively replace and firm the soil around the roots. Modest strength and reasonable dexterity is required for this work.

Auger planting quality is greatly enhanced when preceded by suitable machine or hand site preparation. This treatment should, in addition to reducing competing vegetation, remove ash, organic matter, and dry soil that might get into the planting hole; provide a smooth surface on which the excavated soil may be deposited; and provide a convenient work surface for the planter.

High quality durable equipment is available for planting trees with powered soil augers. The "Cannon DH-2W" auger transmission quickly turns a chainsaw into a very good auger power unit. The 4" "Carbide-1000" and "Thomas Loc-Tip" augers are durable and efficient digging tools which will fit several different auger transmissions. These tools have greatly expanded the range of soil conditions in which auger planting can be used.

There is no magic involved in auger planting. It is subject to poor workmanship as is any other method. However, it is easier for people to plant properly with soil augers, on suitable sites, than with hand tools, if given good equipment, training, and supervision.

The use of soil augers is strongly encouraged throughout the Intermountain Region. Extended (to 16") KCB, or similar planting bars are recommended on sites that are too

stoney for augers. A planting hole broken out on three sides and hand replacement of soil is then required. Planting machines may be used when site conditions, project size, and machine availability make it practicable.

I recently prepared a pamphlet "Planting Tree Seedlings with Powered Soil Augers." It explains in detail some of the requirements and procedures for successful auger planting. It will soon be available from International Reforestation Suppliers, Inc., P. O. Box 5547, Eugene, Oregon 97405. This firm also handles the "Cannon" transmissions and "Carbide" augers. The "Thomas" augers are available from Southern Oregon Reforestation, Inc., 6517 Pioneer Road, Medford, Oregon 97501.

PLANTING QUALITY INSPECTIONS

Planting quality inspections are required on all plantations. Inspections are conducted concurrently with planting operations. The project foreman or the contractor is promptly advised of any inadequate planting quality, or any unsatisfactory procedures that are detected. A two-phase system of inspection has proven most effective.

The first inspection phase is aimed at preventing errors before they occur--or at least confining them to only a few trees. One or more inspectors circulate throughout the planting operation. They watch to see that site preparation, hole opening, and tree handling and planting procedures are correct. They are especially alert to see that trees are properly protected and handled before and during planting, and that forbidden procedures are not used. Errors observed are immediately reported to the foreman or contractor and documented if appropriate.

The second inspection phase is the basis for evaluating project crew performance and for possible adjustment of the per unit bid price for planting contracts. These inspections consist of detailed examinations of the planted trees on a series of 1/50- or 1/100-acre sample plots, aggregating one percent or more of the area planted. All trees on each plot are checked for compliance with elements 1 through 6 as listed in the section "Basis for Quality Planting." The number of trees on the plot which meet this test is the basis for determining the number of trees which are excavated to determine compliance with elements 7 through 11. Trees not in compliance with all 11 elements, as appropriate, are declared "unsatisfactory." Results are documented on a special form for subsequent summary and analysis.

Little variation from prescribed tree care and planting standards is tolerated. For example, trees are considered "wasted" and are discarded if they have been contaminated by petroleum products or fumes. The same applies to those whose roots are exposed to sun and wind by planters carrying them in their hand from one planting hole to another. Experience has shown such trees will die or do poorly. A charge is made for "wasted" trees on tree planting contracts.

Compliance with inspection elements 1 through 6 is easily determined by examination and measurement of surface conditions. Elements 7 through 11 can only be adequately inspected by digging a hole (a round pointed tile spade is preferred) immediately adjacent to the planting hole and gently removing the soil around the tree roots without disturbing the tree. A bulb trowel and an ice pick or awl are excellent tools for this work. Voids (air pockets) are easily detected, and general soil firmness ("as firmly planted as soil conditions allow") is indicated by soil resistance to tools and fingers.

The only deviations from a "near normal" root configuration that is acceptable are those which developed in the nursery. This may be tested by removing the newly planted tree from the planting hole. If the abnormality persists without being held in place by soil, it is accepted.

All roots must extend downward (except as described above), and no degree of "J" or "L" configuration is acceptable.

Trees that are found to be properly planted may be left in place, and moist mineral soil replaced and firmed around the roots. Others should be removed and planted properly.

Inspectors must be well trained and impartial. Each one should plant and then inspect a few trees every few days to maintain a feel for soil conditions. Doubtful situations (is it good or bad?) may be settled on an alternating basis. Foremen and contractors are invited to observe inspections.

The often-used firmness test of tugging on a few needles is inadequate. The top of the planting hole may be easily crimped to hold the tree very tightly, masking loose soil and voids around the roots. Similarly, lifting the tree out in a "plug" of soil, which is then removed to expose the roots, masks errors in planting hole orientation, root configuration, and soil firmness around the roots.

TRAINING

Region-wide tree planting training sessions are held to improve planting quality and, hopefully, plantation performance. The program that evolved has several objectives, including:

Develop a success-oriented attitude about tree planting throughout the Region.

Make all concerned personnel aware of the Seed Zone Program and the need to get the proper species and seed source on each planting site.

Replace incorrect tree handling and planting practices with proven correct standard procedures.

Encourage use of soil auger planting on suitable sites.

Gain acceptance and conformity to the Region-wide standard tree planting contract (now the so-called "Westwide" tree planting contract).

Improve and gain uniformity in planting contract preparation, administration, and inspection.

Increase cooperation between nursery people, contracting personnel, and field technicians and Foresters.

Create opportunities for exchange of ideas and experience across administrative boundaries.

Teach people how to teach successful tree handling and planting techniques.

Attendance at one of these training sessions every 3 years (two or more are held annually at convenient times and locations) is required of all who are responsible for some phase of the planting program. This includes contracting officers and the Lucky Peak nurseryman and assistant as well as reforestation specialists, work supervisors, inspectors, contracting officers' representatives, and Silviculturists. Repeated attendance is required so that those involved can keep current with changes, contribute from their experience, and correct any bad habits they have developed.

Training is conducted by the most qualified reforestation and contracting specialists available. The one-day classroom session consists of a slide presentation depicting the consequences of inadequate consideration of seed source, planting techniques, and plantation protection. Emphasis is placed on the fact that well-grown, handled, planted, and protected seedlings will survive and grow very well. The program is followed by presentations on contracting and administration authorities, project and contract planning and preparation, project supervision, contract administration, inspection, and training.

The second day is devoted to field demonstrations of proper tree handling, site preparation, planting, and inspections. Trainees are required to practice all procedures demonstrated. They also must inspect a plot of trees that contains specific planting errors and report on their findings.

FOLLOWUP

Plantation performance must be monitored. Regional policy requires that at least 25 trees be staked on each plantation when established. More staked trees are required on larger areas. Survival of these sample trees is determined after September 15 of the first, third, and fifth seasons. Survival data, by species, is analyzed for each planting area, Ranger District, Forest, and for the Region as a whole. Costs per acre, per planted tree, and per live tree are derived. Summaries of the data, under a cover letter by the Regional Forester, are circulated to Forests, Ranger Districts, the Lucky Peak and Coeur d'Alene Nurseries, and other interested persons.

Use of "representative" staked rows may have some statistical shortcomings. However, they provide an index of seedling performance by seed lot, planting crew, weather conditions, and other variables which, if adequately documented, can help identify factors that depress seedling performance.

Plantations should be checked several times during the first growing season to identify problems and probable causes. Trees that turn brown a few days or weeks after planting were probably dead, or nearly so, when planted. This would indicate preplanting handling problems. Failure to acclimatize the trees properly may cause the needles and buds to droop or become flaccid a few hours after planting. Trees responding in this manner will probably develop short leaders and needles on the initial growth and suffer depressed growth for some time. Other stressful situations, such as broken dormancy, root damage, and fluctuating storage temperatures and humidities may cause similar symptoms.

Plantations must be visited often enough that damage by gophers and other rodents, livestock, big game animals, and other agents is detected before serious losses occur. Gophers and livestock are generally considered the most serious cause of plantation damage in the Intermountain Region. They are often the leading cause of seedling mortality. It is important that such damage be detected before it becomes widespread and while the causative agent may still be identifed so that appropriate and timely protective or corrective action can be taken.

Trees that are well grown and handled, properly planted on site, and protected, will make good growth from the start. Bud burst and top growth will be near normal, as will needle development. Root growth will be vigorous. Such trees will increase in height (from root collar) by 30 to 100 percent or more the first year, depending on initial height. Growth will accelerate annually until it reaches the site potential.

A means of evaluating plantation growth is badly needed. Efforts are underway in the Intermountain Region to develop meaningful ways of doing this.

One approach, which can be applied as soon as the new growth hardens off the first season is to classify leader/needle development of a sample of trees. Four classes are used: a) normal, b) near normal, c) abnormal, and d) aborted. Experience shows that few of the "a" and "b" trees will subsequently die; while more of the "c" trees and many of those classified as "d" will succumb.

Initial growth can also be used to evaluate performance the summer or fall after planting. However, such measurements must be correlated with seedling size. We have found that the smaller seedlings usually grow less in actual elongation, but more in percentage of initial height, than do the larger trees. Table 1 shows this relationship for 2-0 lodgepole pine planted in 1977 on the Twin Falls District of the Sawtooth National Forest. Seedling performance in terms of leader development class has been included.

Table 1.--Relationship between seedling height when planted (initial height) and leader elongation during the first growing season

	Initial Height	No. Trees in Sample	1st Yr. Growth	Increase in Height	Trees in each leader development class a	b	c	d
	cm		cm	%				
	3	21	2.8	94	11	1	7	2
	4	49	3.5	87	36	2	9	2
	5	70	4.0	80	55	3	9	3
	6	81	4.3	72	67	2	5	7
	7	80	4.9	71	72	2	5	1
	8	70	4.9	61	65	1	1	3
	9	43	5.0	56	36	2	3	2
	10	30	5.8	58	26	1	1	2
	11	21	5.2	48	19	-	-	2
	12	19	6.6	55	18	-	-	1
	13	4	6.3	48	4	-	-	-
	14	5	4.8	34	4	-	-	1
	15	2	4.5	30	1	-	-	1
	16	1	7.0	44	1	-	-	-
Avg.	7.1	496	4.6	65	415	14	40*	27*

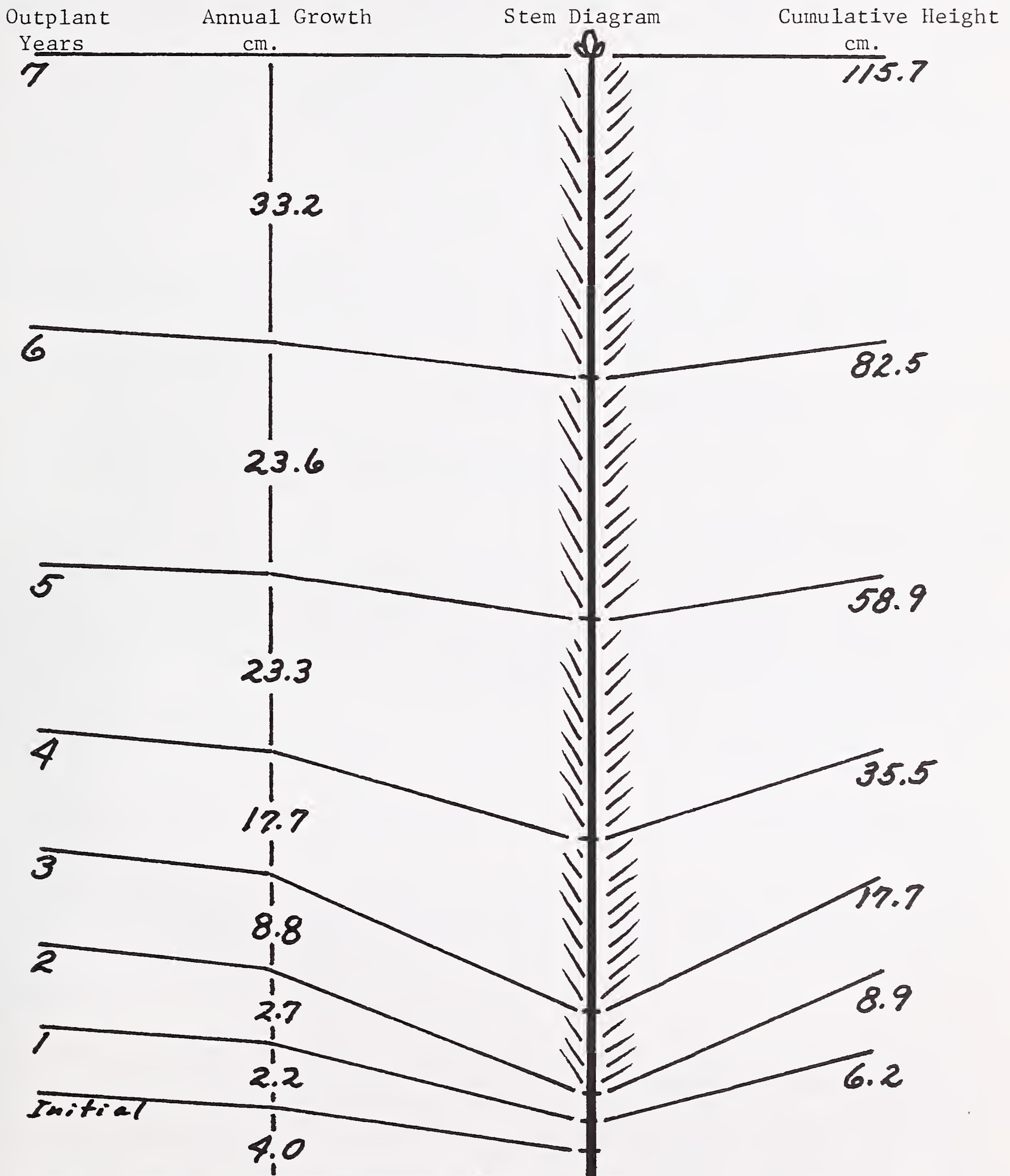
*About 14 percent of the trees fell in the "abnormal" and "aborted" leader classification. This resulted in substantial depression of average growth for the project and provides a clue as to the amount of mortality that can be expected in years 2 and 3.

A third potential means of evaluating growth performance would be through collecting annual growth data on selected plantations for different species and sites. These data could be used to develop "plantation expectation charts" against which the growth of any plantation of the same species on similar sites could be compared at any point in time. This comparison capability would also make it possible to make some predictions as to future plantation performance. Figure 1 is an example of such a chart of the performance of 1-0 ponderosa pine seedlings planted in the Cold Springs area of the Idaho City Ranger District, Boise National Forest in 1974.

Figure 1

Plantation Expectation Chart (Height)

Species - PP; Stock - 1-0; Seed Source - Idaho City; Planted - 1974; H.T. - Not Avail; Site Index - Not Avail; Planting Method - Auger; Planting Quality - Good (90+); No. of Sample Trees - 35; Other - Annual Gopher Control; Location - Cold Springs Creek, Idaho City R.D., Boise N.F.



CONCLUSION

Our experience has shown that we can get excellent survival and growth from planted forest trees throughout the Intermountain Region. I am sure that similar success is attainable over a much wider area. However, it is essential that the basic principles, to which new techniques have been or may be adapted, be closely followed. We have been accused by some of being too "zero defect" oriented. Unfortunately, if you compromise planting quality, allowing a small percentage to die for the sake of economy, a disproportionately larger percentage gets sick, and doesn't perform.

Attention to detail is what counts, and the people who use your trees often don't know the details. Dialogue between nursery people, research people, and those who use the trees will benefit all. Invite those who use your trees to visit your nursery, examine the stock, and discuss details. Provide basic instruction and reference material on provenance, seedling care, planting procedures, and plantation protection to those who may not be aware of these needs. A visit to the "home ground" of some of your "customers" can pay big dividends. Sharing ideas, skills, and concerns helps build the good relationships required for successful plantations. Remember, the order for a few hundred or thousand trees from a small user may have little significance to your operation, but it is extremely important to that person.

Extend your vision and effort beyond the nursery gate--there is a big world out there and a lot of people who need your help.

PUBLICATIONS CITED

Lotan, James E., and David A. Perry
1977. Effects of residue utilization on regeneration of lodgepole pine clearcuts. In Proc. Symp. on Terrestrial and Aquatic Ecological Studies of the Northwest. Eastern Wash. State Coll. Press, Cheney, Wash., March 26-27, 1976 : 125-133

Schmidt, Wyman C., and James E. Lotan
1980. Establishment and Initial Development of Lodgepone Pine in Response to Residue Management. To be published.

U.S. Forest Service
1979. Plantation Survival Records on file in USDA Forest Service Regional Office, Ogden, Utah 84401

U.S. Forest Service
1979, Weather Records on file in USDA Forest Service Regional Office, Ogden, Utah 84401

U.S. Forest Service
1980. Mr. Boether's letter of February 12, 1980, to the Chief, U.S. Forest Service, on file in USDA Forest Service, Regional Office, Ogden, Utah 84401

MINE AND ROADSIDE REVEGETATION IN MONTANA

Intermountain Nurseryman's Association
Western Forest Nursery Council
Boise, Idaho
August 12, 13, and 14, 1980

Bernie Jensen
Assistant Research Range Scientist
Montana State University
Bozeman, Montana

ABSTRACT

Presently in Montana and surrounding states, revegetation research and development activities are being concentrated on the rehabilitation of surface mined lands, while little research is being directed toward roadsides. Rapidly expanding mining activities and increased public concern for the environment have resulted in increasingly high standards for land rehabilitation. These developments are creating numerous challenges and business opportunities for nurserymen and related professions.

INTRODUCTION

I was requested to speak about roadside and mineland revegetation projects and recent developments in Montana. Roadside revegetation research has received little attention and project procedures have remained relatively unchanged during the past three years. However, coal mining related activities in the Western states have increased at an exponential growth rate during the last several years. Consequently, I will direct most of my comments toward the development trends and immediate needs of mining related reclamation programs. Never before has land rehabilitation expressed a greater need for the professional services of nurserymen, landscape architects, botanists, ecologists, and other land rehabilitation specialists. The increasing amounts of land disturbance combined with greater public concern for proper land management practices has resulted in a new era of land rehabilitation. We as a professional group are directly involved and are responsible to meet the higher standards of this new era by developing improved techniques and materials to successfully and economically rehabilitate disturbed lands. Modern land rehabilitation has evolved to a precise scientific field which demands specific procedures and high caliber training.

Recent data indicate that the intermountain area is and will continue to be subjected to extensive mining activity. An Associated Press release summarized the situation as follows. "The states of North Dakota, South Dakota, Colorado, Montana, Wyoming and Utah will be producing 30 percent of the nations coal by 1985, up from 10 percent only five years ago. The region's electric generating capacity will have doubled from 1975 to 1985, increasing from 3 to 5 percent of the nations total. Some 60 percent of the country's uranium will come from the region by 1985, more than

doubling the current 10,000-ton-per-year output. By 1990, half the oil produced in the six states is expected to come from oil shale." The above statistics indicate that the need for land rehabilitation will substantially increase.

CURRENT AND FUTURE EXPECTATIONS

In recent years stringent Federal land rehabilitation requirements have been implemented which require the states experiencing surface coal mining activities to develop and implement equally restrictive requirements (U.S. Office of Surface Mining, 1977). Many western states have developed proposed regulations which are now being acted upon at the Federal level. In the near future I believe many of these restrictive requirements will influence reclamation standards of other projects such as roadsides, utility corridors and urban development. As an example of what may soon confront us, I will read to you selected requirements included in the recently proposed Montana Surface Mining Control and Reclamation Act (State of Montana, 1980).

Please keep in mind, that the primary reason Montana imposed these laws was to prevent the Office of Surface Mining (OSM) and Environmental Protection Agency (EPA) from controlling Montana resource development.

Montana regulations now require that a diverse, effective, and permanent vegetative cover of the same seasonal varieties native to the area of land to be affected be established.

Several of the guidelines used to determine if the above standard for revegetation has been met include the following:

1. Success of revegetation shall be measured on the basis of unmined reference areas approved by the department. The department shall approve the estimating techniques that will be used to determine the degree of success in the revegetated area. At least one reference area shall be established for each native community type found in the mine area.

2. The revegetated areas and their respective reference areas will be evaluated for at least two consecutive years prior to application for bond release and shall include the last two consecutive years of the bonding period. Application for final bond release may not be submitted prior to the end of the tenth growing season.

3. These operators shall initiate a study approved by the department which will demonstrate that the revegetated areas are capable of withstanding grazing pressure.

4. The stocking of trees, shrubs, half-shrubs and the ground cover established on the revegetated area shall be comparable to the stocking and ground cover on the reference area and shall utilize local and regional recommendations regarding species composition, spacing and planting arrangement. The stocking of live woody plants shall be comparable to the stocking of woody plants of the same life form on the reference area. When this requirement is met and acceptable ground cover is achieved, the 10 year responsibility period shall begin.

5. The operator shall utilize seed and seedlings genotypically adapted to the area when available in sufficient quality and quantity.

6. Where tree species are necessary the permittee shall plant trees adapted for local site conditions and climate.

7. The permittee shall consult with appropriate state and federal wildlife and land management agencies and shall select those species that will fulfill the needs of wildlife, including food, water, cover, and space. Plant groupings and water resources shall be spaced and distributed to fulfill the requirements of wildlife.

8. Weighted productivity shall be determined for each of the following morphological classes; annual grasses, perennial grasses; annual forbs; biennial and perennial forbs; and shrubs. The production of each class on the revegetated area shall be comparable to the weighted production for that morphological class.

9. The number of species occupying 1% or more of the ground cover in the revegetated area shall be equal to or greater than the number of species occupying 1% or more of the canopy cover in the reference area.

The above is only a brief introduction to the many challenges facing the land rehabilitation profession. Also keep in mind that similar requirements must be implemented by most states, otherwise OSM will implement their own Federal program.

To date in Montana, we have made excellent progress towards developing techniques for establishing stands of native grasses. Our present "state of the art" can enable us to establish native grass stands which comply with the new standards. However, I feel we are still in the dark ages when it comes to reestablishing suitable stands of native forbs, shrubs and trees. I will comment on five areas of work which will require added effort if we are to comply with the new land rehabilitation standards.

1. Ten years of revegetation research in Montana has shown that many native forb, shrub and trees cannot be successfully established if seeded with grass species. Many of the natives are difficult to establish from seed if competition from other species is not reduced or eliminated. If direct seeding techniques are not successful and the species are required for successful land rehabilitation, then transplanting techniques must be implemented. This requires that large quantities of high quality native plant species not commonly available will need to be produced. This is not an easy task because many of the most desirable species do not readily lend themselves to present day propagation and production methods. Persons entering this field will require a substantial amount of information and training regarding individual species characteristics. Management methods necessary to produce native plant materials will become more complex. Most native plant production will require long-term contracts to insure production of the required number of each species, to specify plant sizes, to designate source of parent material and to insure proper delivery time. Presently within the intermountain region there are several nurserymen producing native plant material for large scale land revegetation. Although these businesses have had their share of problems they are expanding these services and will be capable of supplying plant material not available from other suppliers.

2. A second area requiring additional effort is that of developing efficient handling and planting methods for large numbers of plants. Although transplanting of bare rootstock has been successfully practiced for many years, it is labor intensive, produces variable establishment rates and has resisted total mechanization. Presently this method is considered inadequate for large scale revegetation projects. Recent emphasis on development of containerized transplant stock for reforestation and land revegetation has resulted in a wealth of new techniques and materials. Much of this work directly applies to our need to establish native species on mine spoils.

Containerized planting system development has resulted in numerous container types and propogation methods. I believe it is still too soon to make final decisions as to which systems are most suitable. All these innovative systems must be intensively field tested to determine advantages and disadvantages. Most likely there will be no single type and size of container propagation method and planting procedure which is best for all conditions. More cooperative research and system evaluation is needed to help define what methods perform best under specific conditions.

At Montana State University we have concentrated our efforts on developing what we call the dryland tubeling (Jensen and Hodder, 1979). This method was developed primarily for establishing shrub and tree species in semiarid harsh environments. The 2 inch diameter by 24 inch long paper and plastic container is designed to position the root system of a well developed juvenile shrub or tree deep in the soil where soil moisture is more readily available and where root system competition is reduced. This method has proven successful in semiarid eastern Montana. We have now progressed to the point where planting is completely mechanized. Working in cooperation with the Missoula Equipment Development Center (U.S. Forest Service) a machine has been developed which will plant a dryland tubeling within a one minute cycle time. The machine attached to a tractor's 3 point hitch, is basically simple in design and should prove to be highly reliable. We hope to have this machine perfected to enable manufacturing by the spring of 1981.

3. Earlier I mentioned that direct seeding of many native species has not proven highly successful. However, this does not mean there is not or will not continue to be a need for seed of native plants. Presently the demand for native plant seed greatly exceeds the supply. Large quantities of native grass and forb seed are being produced on agricultural lands and harvested from native stands. With the implementation of the new land rehabilitation standards demand for native seed supplies is bound to increase at an exponential rate. Presently there is urgent need to have more seed grown or collected within a reasonable distance of the major soil disturbing projects. Also smaller quantities of seed for site specific species will need to be collected for the propagation of the required transplant stock. In short, a need still exists for more people to be involved in native seed production and collection.

4. A fourth area requiring additional work by land rehabilitation professionals is that of developing improved methods and capabilities for salvaging and reestablishing mature native plant materials. Land disturbances destroy vast quantities of native plant material that is irreplaceable by conventional standards. In areas such as eastern Montana, development of mature shrubs and trees may require 10 to 20 years. Destroying such material is an unexcusable waste if methods are available to salvage and reestablish the vegetation. Salvaging mature trees and shrubs with the tree spade is becoming a routine practice at many strip mines in Montana, Wyoming and Colorado. In recent years transplant survival rates have improved because handling techniques have been refined, species requirements are becoming better known and above-ground plant size is being balanced in relation to rootball size. Research and development work completed at Montana State University has produced two methods of salvaging and reestablishing shrubs. One method referred to as rootpad transplanting involves preparing the shrub for transplanting by first mowing the tops off the shrubs to within approximately 4 inches of the soil surface. A large capacity front-end loader is then used to carefully excavate at a depth of approximately 12 inches by scooping horizontally underneath the rootpad until the bottom of the bucket

is covered. The shrub pad is lifted and transported to the planting site. The bucket is gradually tipped as the loader moves backward, thus sliding the rootpad off the bucket and into the planting depression. Following unloading of the shrub rootpad, topsoil is filled in around the edges of the pad and into all cracks that developed while unloading. The soil can be pressed in place by running a light rubber tired vehicle around the perimeter of the pad or by packing with the bottom of the bucket. Rootpad transplanting establishes masses of shrubs such as native snowberry and rosebush within one year of transplanting. This method is excellent for landscaping around rest areas or for establishing erosion resistant vegetation in drainage ditches. The second method of transplanting shrubs is called shrub root sprigging. This method was developed to use rhizomatous root systems capable of withstanding disturbances. Root sprigging is generally used for planting large areas of low density plants. The first step in root sprigging is to locate sources of desirable plant material on terrain suitable for equipment operation. Next a flail or rotary type mower suitable for cutting brush is used to remove top growth to within approimately 4 inches of the soil surface. The remaining top growth and rhizomatous root systems are then excavated with an agricultural type plow or similar implement and a front-end loader. No effort is made to keep the roots and soil consolidated. The root-soil mixture is then trucked to the planting site where it is uniformly spread over the planting area. The root systems are then completely covered with approximately 4 inches of good quality topsoil. An improved method of shrub sprigging is presently being developed by Montana State University, Reclamation Research Unit and the Vegetative Rehabilitation and Equipment Workshop. A machine, similar to a potato picker has been designed to separate root systems from the soil. The root systems are loaded directly into a modified manure spreader which is used to transport and spread the roots over the planting area. A scraper then covers the root systems with 6 inches of topsoil.

Both shrub root sprigging methods have established excellent stands of the shrubs, woods rose and common snowberry on roadside and on mine spoil research plots. This method can be easily implemented using commonly available construction equipment or the more recently developed root harvesting machines. Implementation of this technique should prove useful for rapidly stabilizing critical drainage areas with an erosion resistant stand of shrubs.

Progress is being made toward the ultimate goal of salvaging and reestablishing all desirable native plant material before an area is disturbed. However, I believe we have only scratched the surface toward what can ultimately be accomplished in this area.

5. A fifth area of importance is the need for a program emphasizing information exchange and continuous education. In order for professionals and businesses to attain up-to-date expertise and maintain a high level of performance in this rapidly progressing science a strong self-education program must be implemented. It is the responsibility of every professional to seek the latest in technology and to inform others of their capabilities. The above needs can be partially fulfilled by attending professional meetings, reading professional publications and exchanging ideas with other progressive scientists and businessmen.

SUMMARY

In summarizing what I have commented on it becomes clear that the role of nurserymen and related professionals must be expanded to include rehabilitation of disturbed lands. These people will ultimately be expected to provide many of the services required to meet the new reclamation standards. Personally, I believe you are entering a challenging era which will provide profitable business opportunities for those willing to pursue land rehabilitation projects.

PUBLICATIONS CITED

Jensen, I.B. and R.L. Hodder. 1979. Tubelings, condensation traps, mature tree transplanting and native root system transplanting techniques for tree and shrub establishment in semiarid areas. Mt. Agr. Exp. Sta. Res. Rep. 141 Vol. 2, Mt. State Univ., Bozeman, MT, 105 p.

State of Montana. 1980. Administrative Rules of Montana 26.4.301 - 26.4.1246.

U.S. Office of Surface Mining. 1977. Surface mining reclamation and enforcement provisions. Fed.-Reg. 42(239): 62639-62716.

IMPACT OF DESERT FORESTRY ON THE PLANT MATERIALS SYSTEM OF NEVADA[1]

Matthew Frolich[2]

ABSTRACT

The desert forestry program in the State of Nevada has given rise to several problems at the nurseries. This paper explains the background of the major problems and suggests possible means to mitigate them.

INTRODUCTION

The development of desert forestry as a new concept in the plant materials system is bringing about basic changes in the state nurseries. These changes are being manifested in management, production and customer relations. The most important changes and their relationship to physical conditions and policy are considered in the text. Solutions or mitigating programs are also considered that show some promise for management.

WHAT IS DESERT FORESTRY?

Nevada can be described as the driest state in the United States. It is almost entirely within the Intermountain Basin, the landscape being largely characterized by Sagebrush, Greasewood and Pinyon-Juniper types. Small wonder that the state found it necessary to define a kind of forestry that could be workable in this arid land. Our 1975 Legislature defined desert forestry as "the science of developing, caring for or cultivating conservation plant materials in an environment by modifying their response to adverse growing conditions while minimizing the consumptive us of water." I am sure you can readily see a couple of potential areas for action in carrying out the thrust of the definition.

How can the response of plant material be modified to adverse growing conditions? The only practical ways that are available to us now are pruning and the use of films to reduce transpiration. Any problem in desert forestry that follows this path, however, will be highly restricted as the costs are quite high.

---

[1]Intermountain Nurseryman's Association, Boise, Idaho, August 14, 1980

[2]Nursery Coordinator, Nevada Division of Forestry, 201 South Fall Street, Carson City, Nevada 89710

Minimizing the consumptive use of water opens a wide, promising avenue in the selection of adapted species. This particular field not only presents us with a wide number of choices, it also presents us with an attainable goal. There is no doubt that this is our greatest potential, but a serious set of problems emerge that have an effect on our nursery operations. Following is a consideration of those problems on the nurseries that supply conservation plant materials.

THE GEOGRAPHY OF NEVADA

The problems we have found in matching the thrust of desert forestry to our plant materials program are closely tied to geography. A brief look at the conditions found in Nevada will be enlightening.

Nevada is characterized by a wide variety of geographical conditions. A look at the map will show you why. The north-south distance is about 475 miles, each to west about 375 miles. In this expanse we have elevations from 500' to 13130' above sea level and a multitude of mountain ranges in a more or less north-south orientation. Each mountain range has a moist side and a dry side. The valleys usually have closed drainage systems with dry lake beds and considerable areas of alkaline soils.

Strong winds are found everywhere in the state. Periodically, winds in excess of 100 miles per hour are reported in northwestern Nevada. Abrasion of plant tissue by blowing sand (or ice crystals) is not unheard of. Wind can also do strange things to nurseries; a consignment of containerized ornamental plants lost 90% of light soil mix in the containers in one afternoon of wind in the Carson City area.

Temperatures cover a wide spectrum. A portion of our state extends into margins of the Sonoran Desert along the lower Colorado River. Here the coldest temperatures may be 25°F or above. In fact, at Laughlin, Nevada there are some decendents of the original date palms introduced into the United States. The northeastern part of the state has the other extreme - low temperatures with a protracted winter. In between we can find almost everything else. In western Nevada storms blow off the mountains at any time of the year. Late frosts are commonplace. Diurnal temperature fluctuations in excess of 60°F occur in July and August in the northern area, fluctuation in the south at the same time may be only a few degrees.

Precipitation may be as little as 2 inches per year on the eastern slopes of the mountains to more than 40 inches at the upper elevations on the western slopes. Evaporation rates vary from 36 inches in the western mountains to 82 inches in the southeast and pose a very special problem in establishing plant materials. It is pretty close to miraculous when plant material is established with 2 inches of rain, summer temperatures in excess of 110°F, intermittent winds carrying abrasive sand and an evaporation rate of 82 inches!

It is no wonder that desert forestry has had an impact on the plant materials system. To fulfill the directive of the law, a large number of species and selections will have to be screened to find those suitable for each of the many specific geographical locations within the state. Those that are successful will be incorporated into the production schedules of the nurseries. Record keeping will have to be increased and more importantly to the nurseryman, propagation and growing facilities become more complex.

THE ROLE OF THE FORESTERS

Those of you who are managing forest nurseries are already working closely with foresters in the field. They recognize and select the genetic material that is to be used for reforestation programs in their districts. The cones are collected and delivered to you and it is then your responsibility to clean and store the seed to produce plant material on their demand. The nurseryman who is growing windbreak material for the general public, on the other hand, has a lot of fun trying to outguess his market. Fortunately, many of the species are standard and can be used over a wide area. The introduction of new selections for specific sites, though, cannot be done by the nursery manager. Field personnel become an integral part of the nursery be assuming a role similar to the forester in selecting genetic material for the nurseries.

The service forester as an active agent of the nurseries will assume a certain amount of control over nursery management. The responsibility cannot be taken lightly if the program is to succeed. This person must be aware of the many parameters imposed by specific sites and must recognize those plant species that will enhance the chance of success in the program. He must also monitor the plantings over time to build stability into the plant materials program. Long term success is not built on the capricious addition or deletion of plant species in the production schedule.

A second vital function that must come from the field is the estimates of plant materials needed. Plant production far in excess of need is not economical and too few may not accomplish what the forester wants to do.

THE NEW NURSERY

As the desert forestry has developed in Nevada, six major problems have emerged. They range all the way from internal changes in management to dealing with the clientele.

A problem has developed in management that is rather extensive. Mention has already been made about the role of field personnel in selecting and designating quantities of material needed in the program. It is difficult enough for one person to set budgets under an enterprising system, let alone widely dispersed individuals. We find that there is a reluctance on the part of the newly enlisted field personnel to set targets for production and sales. This imposes a certain amount of adroit footwork upon the management to meet the budget requirements as set by the oversight agencies of legislature and administration.

The nursery operations themselves have revealed four problems. One is the seed bank. Many of the species that will be introduced will be collected from the wild. Arid land plants are notorious for erratic seed production, some only setting crops at intervals of 10 years or more. Storage of this material to keep it viable is very often on a hit or miss basis. There will be erratic production of native plant species until a reliable source of seed is obtained or until storage proceedures have been worked out for the difficult subjects.

The second problem in nursery operation is closely related - propagation. We simply do not know the requirements for successful germination of some of these species. Shortages of certain species can be anticipated simply because we have not provided the conditions necessary for germination and growth.

Thirdly, a wide spectrum of plant material imposes an economic problem on production . There are so many different plants requiring their own growing conditions that the greenhouse beds are fragmented. We cannot as yet predict very well the time required for production of all species of plants handled by our nurseries.

The last problem we have encountered revolves around our decision to produce in containers. We have selected a container that is cheap, of adequate size, but not very durable. Distribution of nursery stock has become a problem because of the weight involved. Thus far we have been keeping the light weight soil additives at a minimum because of the clay soils we have encountered in the planting sites. Heavy trucks are necessary for transporation to distribution points in the state.

Our only problem we have encountered in dealing with the clientele is one of timing. Containerization has lengthened the planting season, but the typical customer wants to plant in the spring. Monetary restrictions forbid the construction of extensive nursery equipment to enable the program to exist on spring sales alone.

CAN ANYTHING BE DONE TO EASE THE IMPACT?

The nursery manager, like everyone else finds it very easy to list the woes that accumulate from a new program. The responsibility of the manger is not to stop there, but to proceed with the program, solving those problems so as to bring the new program into existence. We can draw from our experience and propose some proceedures that could be employed in the early planning period that would have made our changeover easier to accomplish.

Of course, the uppermost question is "how can this program be implemented?" And, of course, no answer can be found without understanding. A definition is needed that is clearly understood and agreed upon by the policy makers, administration, oversight agencies and the action agency that clearly defines the mission and the limits of the new proposal.

After this agreement has been reached, the action agency should embark on an investigative program that has the thoroughness of a systems analysis. After all, the manager of the action agency is the person who is supposed to do the budgeting and the time frame reference for the project. He simply cannot institute a complicated program without having the best information possible. Admittedly, no one has succeeded in gathering all of the information about any project, but mistakes in committment are inversely proportional to the body of knowledge.

Management must make accurate estimates of the resources needed to accomplish the mission. The manager must justify the expenditure of funds to obtain the necessary equipment and the necessary positions. Do not forget that the cost of training is as much as part of development as is the cost of a new greenhouse.

Position descriptions and responsibilities must be clarified early in the program. Once the level of responsibility and area of responsibility of each actor is understood, many of the problems of management are mitigated. Personnel management must be based on who is responsible for what.

Pursue the course of action with deliberation. The addition of too many activities and functions in a short period of time results in confusion, hard feelings and the inevitable delay. There will be problems that crop up that no one could anticipate. When time is planned into the change over period these can be handled without becoming crises.

For the internal problems of production, remain flexible. Add or subtract species in the production schedule only with good justification. Use small units for seed treatment and germination so that specific growing conditions can be provided. Keep equipment as "general" as possible. The nursery will have to supply small quantities of plant materials for specific uses.

Consider seed orchards as an integral part of the nursery. Control of seed collection and production would be concentrated and more easily facilitated. A higher production of seed would be anticipated and that would reduce storage problems.

Integrate a distribution system with the necessary transport within the nursery. The initial cost may be high, but the loss of some management decisions to the field personnel can be made up in part by better distribution. Plant losses are at a minimum if the responsibility of distribution rests with the nursery. The weight problem may be mitigated as more knowledge is gained about the planting sites.

It will not be easy to change the habits of the clientele. We are now developing an informational program to show the advantages of planting at different seasons of the year. For Nevada, we really need three programs, one for each of the major areas. Eventually, the plant materials program, through the field personnel will become a positive benefit to the people of the state.

Evaluations will have to be frequent and honest. The final criteria for success will be determined by the clientele of the program.

NURSERY MANAGEMENT INFORMATION SYSTEM[1]

Thomas E. Williams[2]

ABSTRACT

In 1978 a committee was established to prepare a proposal for automating and standardizing current nursery record-keeping and report preparation procedures. The system is designed to generate reports and document the history of seedlings and their treatments from seed to established seedlings. Based on the committee work over the past three years and the pilot testing conducted at the Fort Collins Computer Center (FCCC) we propose to implement this system on microprocessor equipment located at each nursery handling a significant volume of business.

The paper presented at last year's Intermountain Nurseryman's Association Meeting summarized the initial steps toward developing a national Nursery Management information System. This paper will outline the activities which have taken place since that time.

The current nursery volume of business plus predicted increases in the future demonstrate that efficient nursery management is contingent on developing a automated system of managing data, generating report and providing historical records.

The initial efforts toward achieving this objective began in 1978 when a committee composed of representatives from Regions 2, 3, 5, 6, 9 and WO-TM met at Fort Collins to prepare a proposal for developing a Servicewide Nursery Management Information System. This proposal was sent to all Regions for their assessment of compatibility with their operations. After evaluating the Regional responses our committee prepared a feasibility report which designated Medford and Wind River Nurseries to participate in a pilot test of the system. To demonstrate the need for an automated system all Regions supporting nurseries were contacted regarding their present and expected volume of business in 1985. Their responses indicated that by 1985 we can expect a 250% increase in number of seed lots grown and a 175% increase in the number of shipping transactions per year.

To further assess the need for an automated Nursery Management System the objectives listed below were addressed during the pilot test.

1. Accurately storing and retrieving large amounts of information.

2. Personnel saving (more efficient use of people).

---

[1] Paper presented at the Intermountain Nurseryman's Association Meeting, Boise, Idaho, August 11-14, 1980.

[2] Nursery Manager Assistant, USDA Forest Service, Region 6, Rogue River National Forest, Medford Forest Nursery, Central Point, OR. 97502

3. Timely response to reporting requirements and special queries.

4. Historical records for evaluation of past practices and to "track" stock problems.

5. Establish more effective communications between nurseries.

6. Tie seed and tree performance to land treatments and nursery practices.

7. Refinement and improvement of nursery sowing factors.

Coincident with the pilot test at the two nurseries, FCCC personnel have been working with Medford Nursery personnel in developing draft Field Data Forms. One of these - the Seedling Request Form - has been sent to the field for use in ordering seedlings this year.

Seedling history data from Medford and Wind River nurseries have been entered, edited and loaded into a S2K Data Base which allows us to gain experience with the capabilities of the system.

Most of our recent activities have been with the seed analysis portion of the NMIS. The number of required input and output records have been defined and the logical data structure completed for the seed. This logical data structure will be used in the development of the seed Field Input Forms.

FCCC personnel have analyzed the results of the pilot test conducted at Medford and Wind River nurseries using the Fort Collins computer and the consensus is that a microprocessor located at individual nurseries would best satisfy our needs. This decision was arrived at primarily because of the following concerns:

1. Nursery personnel were, and still are, required to come to work before normal working hours or to remain after normal working hours in order to gain access to FCCC.

2. Due to poor communication facilities at the nurseries, nursery personnel found it difficult to stay connected to the Fort Collins computer for long periods of time.

3. There is no easy method of generating and/or receiving formated reports (5 to 50 pages) at the nursery.

Two additional factors were considered in arriving at this decision to use microprocessor equipment.

1. The system is a recordkeeping and reporting system and does not require sophisticated analytical tools.

2. No one except nursery personnel need access to the nursery data except in the form of reports.

Our initial assessment of costs comparing the manual system, use of FCCC and using a microprocessor indicate the most efficient system to be the microprocessor.

The decision to go with a microprocessor was followed by another cost comparison between two brands of equipment, the TRS80 Model II by Radio Shack and the DS990 Model I by Texas Instruments. The NMIS could be implemented on either microprocessor. A significant cost differential exists between the two types of systems, however, we propose to go with the DS990 System at an initial cost of almost double the TRS80 Model II System, for the following reasons:

1. Procurement under the current Departmental Contract gives a better foundation to work from if any vendor related problems occur.

2. Purchase of Texas Instrument hardware will allow us to participate in and benefit from standardization of equipment and training within the Forest Service.

3. Texas Instrument has more experience in the development of production oriented hardware than Radio Shak - Tandy Corporation.

4. Procurement time is faster under existing Department Contract.

5. A formal training package for operation and programming on the Texas Instrument equipment will be available.

6. A good Data Entry Language exists for the DS990 equipment.

7. The DS990 system allows for index sequential files.

Where do we go from here? Prior to the system becoming operational the following activities need to be addressed.

1. Acquisition of hardware.

2. Preparation of software.

3. Preparation of final field input forms.

4. Provide training for personnel using the microprocessors.

5. Conduct meeting with Regional and Nursery personnel to demonstrate and explain the system.

6. Prepare implementation schedule to determine order in which other nurseries will acquire the system.

Our target date for system implementation mentioned at last year's meeting has been delayed somewhat due to accessibility of hardware and software, however, we hope to have the entire system with documentation operational by 1/1/81.

Dick Altmann
Pine Ridge Forest Nursery
P.O. Box 750
Smokey Lake, Alberta, Canada TOA 3CU

Peter N. Au
Pine Ridge Forest Nursery
P.O. Box 750
Smokey Lake, Alberta, Canada TOA 3CU

Herbert Baer
Clotilde Merlo Forest Nursery
Louisiana-Pacific Corporation
1260 Spring Street
Arcata, California 95521

Dirk Barel
Weyerhaeuser Company
505 N. Pearl Street
Centralia, Washington 98531

Jerry Barnes
Weyerhaeuser Company
16004 Pletzer Road S.E.
Turner, Oregon 97392

Tom Berkemeyer
Simpson Forest Nursery
Simpson Timber Company
Korbel, California 95550

Jim Betts
5301 Colbertson Road
Parkdale, Oregon 97041

Alfred Borchert
Horning Seed Orchard
P.O. Box 36
Colton, Oregon 97017

Charles Brown
Forest Service - Retired
Eureka, California 95501

James A. Bryan
Washington Forest Nursery
Weyerhaeuser Company
8844 Gate Road S.W.
Olympia, Washington 98502

John Bryson
Texas Forest Service
Rt. #3, P.O. Box 216
Lubbock, Texas 79401

Gary Burson
Tyee Tree Nursery
P.O. Box 8
Umpqua, Oregon 97486

Bill Butler
Northwood Pulp (Woods Div.)
P.O. Box 9000
Prince George, B.C., Canada V2L 4W2

Ken Cameron
Champion International
970 Wasson
Lebanon, Oregon 97355

Larry Catton
Simonson Lumber Company
4741 Wonder Stump Road
Crescent City, California 95531

Dr. Brian Cleary
Oregon State University
Forestry Extension Service
Corvallis, Oregon 97330

Sally Cooley
USFS FIDM
P.O. Box 3723
Portland, Oregon 97208

Ed Cordel, Pathologist
Southeast Area S&PF
USDA Forest Service
P. O. Box 2750
Ashville, North Carolina 28802

Kenneth Curtis
Department of Natural Resources
Webster Forest Nursery
Olympia, Washington 98504

Al Dahlgreen
P.O. Box 472
Leavenworth, Washington 98826

David Davis
Bend Nursery
21692 McGrath Road
Bend, Oregon 97701

Roger Davis
Oklahoma Forestry Division
122 State Capitol
Oklahoma City, Oklahoma 73105

N. Diamond
Bend Nursery
USDA Forest Service
63095 Deschutes Mkt. Rd.
Bend, Oregon 97701

Jack Doty
Viewcrest Nurseries
9617 N.E. Burton Road
Vancouver, Washington 98662

Kerwin Doughton
Tyee Tree Nursery
P.O. Box 8
Umpqua, Oregon 97486

Mike Dulik
Makah Tribal Forestry
P.O. Box 115
Neah Bay, Washington 98357

Dave Dutton
Wind River Nursery
Carson, Washington 98610

Dr. George Edwards
Canadian Forestry Service
Pacific Forest Research Centre
506 West Burnside Road
Victoria, B.C., Canada V8Z-1M5

Rex Eide
Industrial Forestry Association
1887 North Holly Street
Canby, Oregon 97013

Boyd Elliott
Albuquerque Nursery
USDA Forest Service
517 Gold Ave. S.W.
Albuquerque, New Mexico 87102

Orville Engelby
USDA Forest Service R-4
Federal Building
324 25th Street
Ogden, Utah 84401

James E. Ficke
State & Private Forestry
11177 W. 8th Ave.
P.O. Box 25127
Lakewood, Colorado 80225

William Fisher
CS&KT Forestry
P.O. Box 194
Arlee, Montana 59821

Lou Forcier
Ministry of Natural Resources
Nursery Superintendant
Swastika Forest Station
P.O. Box 129
Swastika, Ontario, Canada POK ITO

Paul Forward
J.W. Toumey Nursery
USDA Forest Service
P.O. Box 445
Watersmeet, Michigan 49969

Daryl A. Genz
Nursery Supervisor
Champion Timberlands
P.O. Box 939
Plains, Montana 59859

Steve Gibbs
Int'l Reforestation Suppliers
P.O. Box 5547
Eugene, Oregon 97405

Gerry Genovese
Syncrude Canada
P.O. Box 4009
Fort McMurray, Alberta, Canada
Mail Drop 0078 T9H 3L1

Richard Gilmore
North Dakota Forest Service
308 First Street
Bottineau, North Dakota 58318

John Grimm
Industrial Forestry Association
7515 Meridian Road S.E.
Olympia, Washington 98503

Ralph Gray
Gray Co. Harvester
P.O. Box 86
Heidelberg, Ontario, Canada NOB IYO

Davis Grierson
Utah State Seedling Nursery
Draper, Utah 84020

Preston Guthrie
Bureau of Indian Affairs
Branch of Forestry
P.O. Box 8327
Albuquerque, New Mexico 87198

Mahlon Hale
Bend Nursery
USDA Forest Service
63095 Deschutes Market Road
Bend, Oregon 97701

Oscar Hall
Wind River Nursery
Carson, Washington 98610

David C. Hansen
USFS Wind River Nursery
Carson, Washington 98610

Chuck Hayhurst
Bureau of Land Management
P.O. Box 2965
Portland, Oregon 97208

Stephen M. Hee
Washington Production Manager
Weyerhaeuser Company
P.O. Box 527
Rochester, Washington 98579

Dan Hendricksen
Utah State Seedling Nursery
Draper, Utah 84020

Willis J. Heron
Division of Forestry
2705 Spurgin Road
Missoula, Montana 59801

John H. Hinz
Lucky Peak Nursery
c/o Idaho City Stage
Boise, Idaho 83706

Dick Holland
Washington State Nursery
3875 Guide Meridian
Bellingham, Washington 98225

Gordon Howe
Tree Nursery Division PFRA
Indian Head, Saskatchewan SOG 2KO

Ralph F. Huber
Canadian Forestry Service
Northern Forest Research Centre
5320 - 122 Street
Edmonton, Alberta, Canada T6H 355

Jukka Heikurinan
Rt 1, Site 1, Box 2
Coppercliff, Ontario, Canada POM INO

Ed Hardin
435 N.W. Maxine
Corvallis, Oregon 97331

R. Iverson
WFRE International Paper Co.
34937 Tennessee Rd.
Lebanon, Oregon 97355

Ms. Annabelle Jaramillo
Pacific Northwest Experiment Station
USDA Forest Servic
3200 Jefferson Way
Corvallis, Oregon 97331

Bernie Jensen
Montana State University
103 Linfield Hall
Boseman, Montana 59717

Loring M. Jones
Northplan Seed Producers
Route 1
Eagle, Idaho 83616

Glenn Jacobsen
Payette National Forest
P.O. Box 1026
McCall, Idaho 83638

James F. Kayler
Fantasy Farm Nursery
Route 2
Lenore, Idaho 83541

Robert Klapprat
Ontario Ministry of Natural Resources
Route 4
Kemptville, Ontario, Canada KOG 120

C.J. Sally Johnson
6511 203 Avenue S.W.
Centralia, Washington 98531

Lovelle Lack
Industrial Forestry Association
1887 N. Holly Street
Canby, Oregon 97013

Tom Landis
USDA Forest service
Mt. Sopris Nursery
Route 1, P.O. Box 110
Carbondale, Colorado 81623

Glenn Lehar
Tyee Tree Nursery
P.O. Box 8
Umpqua, Oregon 97486

Jack Marshall
USFS FI&DM
1075 Park Blvd.
Boise, Idaho 83702

Rod Matye
Westfir Nursery
46375 Highway 58
Westfir, Oregon 97492

Wayne Mauhs
Champion Timberlands
P.O. BOX 8
Milltown, Montana

John McClatchey
USDA Forest Service
P.O. Box 315
Corvallis, Oregon 97330

Jim Meyer
University of Idaho Forestry
Moscow, Idaho 83843

Ross Meyers
Oregon Forest Nursery
Weyerhaeuser Company
P.O. Box 547
Turner, Oregon 97392

Rod Miller
Aurora Forest Nursery
Weyerhaeuser Company
P.O. Box 235
Aurora, Oregon 97002

Bart Mortensen
Colo-Hydro
Longmont, Colorado 80501

Calvin Mukumota
Makah Tribal Forestry
P.O. Box 115
Neah Bay, Washington 98357

R. Max Peterson, Chief
USDA Forest Service
P.O. Box 2417
Washington, D.C. 20013

Patrick M. Murphy
Nevada Division of Forestry
201 S. Fall Street
Carson City, Nevada 89701

Alan Myatt
Oklahoma Forestry Division
Route 1, P.O. Box 44
Washington, Oklahoma 73093

Lewis Nicholson
Timber Management Staff
USDA Forest Service (R-6)
P.O. Box 3623
Portland, Oregon 97208

Carlos L. T. Noquez
Forestry Division
P.O. Box 23367
GMF, Guam 96921

David Olson Jr.
Pacific Southwest Experiment Station
USDA Forest Service
Arcata, California 95521

Ed Olson
Wind River Nursert
Star Route
Carson, Washington 98610

Mike Panelli
USDA Forest Service
P.O. Box 1390
Klamath Falls, Idaho 97601

Steve Pendleton
Native Plants
2842 S. W. Temple
Salt Lake City, Utah 84115

Verna Reedy
Champion Timberlands
P.O. Box 939
Plains, Montana 59859

Frank Rothe
555 Ute Highway
Longmont, Colorado 80501

Craig Royce
Phipps State Forest Nursery
Rt. #3, P.O. Box 193
Elkton, Oregon 97436

Russ Ryker
Intermountain Forest & Range Exp Station
316 E. Myrtle Street
Boise, Idaho 83706

John R. Scholtes
Mt. Sopris Nursery
USDA Forest Service
0448 Valley Road
Carbondale, Colorado 81623

Hank Schroeder
4641-196A Street
Langley, B.C.
V3A 5H1

Randy Selig
P.O. Box 555
Elkton, Oregon 97436

Marv Shearer
Extension Irrigation Service
Agricultural Engineering Dept.
Oregon State University
Corvallis, Oregon 97331

Jimmy Sedore
9805 Blomberg Rd. S. W.
Olympia, Washington 98504

May Solomonson
Industrial Forestry Association
463 Eadon Road
Toledo, WA 98591

Tom Smith
Bureau of Indian Affairs
Branch of Forestry
P.O. Box 8327
Albuquerque, New Mexico 87198

George Shikage
Vancouver Bio-Machine Systems
107-13375 76 tj Avenue
Surrey B.C.
Canada V3W-613

Rebecca Stakes
USDA Forest Service
P.O. Box 309
Petersburg, Alaska 99833

Richard Schaefer
Potlatch Corp.
P.O. Box 1016
Lewiston, Idaho 83501

Jim Sweeten
B. C. Forest Service
3605 192nd Street
Surrey, B.C. V354N8, Canada

Ian B. Thain
Bio Energy Development Corp
P.O. Box 1801
Hilo, Hawaii 96720

Richard Thatcher
Lucky Peak Nursery
c/o Idaho City Stage
Boise, Idaho 83706

Barbara E. Thompson
WFRC International Paper Co.
34937 Tennessee Rd.
Lebanon, Oregon 97355

Gene Thornton
H-H Forest Tree Nursery
P.O. Box 479
Sebastopol, California 95472

Mark E. Triebwasser
Weyerhaeuser Company
8844 Gater Rd. S. W.
Olympia, Washington 98502

H. Gus Underkofler
Anchor Seed Orchard
Champion Timberlands
P.O. Box 50 Cow Creek Road
Azalea, Oregon 97410

Mark E. Webb
SRB Box 7441
Palmer, Alaska 99645

K. Watson
Northwood Pulp and Timber Limited
P.O. Box 9000
Prince George, B.C.
BC V2L 4W2

David L. Wenny
Forestry Department
University of Idaho
Moscow, Idaho 83843

Donald E. Wermlinger
Lucky Peak Nursery
c/o Idaho City Stage
Boise, Idaho 83706

Tom Williams
T. W. Williams Co.
I-T Seed Farms, Inc.
New Plymouth, Idaho 83655

Scott Wolff
Ext. Tree Seed Certification
Oregon State University
Corvallis, Oregon 97330

Adolf Wynia
Thunderbay Ontario Canada
RR #1 P7C 4T9 OMNR

Robert E. Zeller
ITT Rayonier, Inc.
P.O. Box 539
Hoquiam, WA 98550

Frederick Zensen
Coeur d'Alene Nursery
USDA Forest Service
3600 Nursery Road
Coeur d'Alene, Idaho 83814

Robert Zobel
Greener N Ever Tree Farm & Nursery
8940 Carmel Valley Road
Carmel, California 93921

☆ U. S. GOVERNMENT PRINTING OFFICE: 1981—777-028/76 REGION NO. 8

USDA Forest Service.
1981. Proceedings of Intermountain Nurseryman's Association and Western Forest Nursery Association Combined Meeting [August 12-14, 1980, Boise, Idaho]. USDA For. Serv. Gen. Tech. Rep. 109, 148 p.

Contains 27 papers presented at the combined meeting of the Intermountain Nurseryman's Association and Western Forest Nursery Association held in Boise, Idaho, August 12-14, 1980.

The Intermountain Station, headquartered in Ogden, Utah, is one of eight regional experiment stations charged with providing scientific knowledge to help resource managers meet human needs and protect forest and range ecosystems.

The Intermountain Station includes the States of Montana, Idaho, Utah, Nevada, and western Wyoming. About 231 million acres, or 85 percent, of the land area in the Station territory are classified as forest and rangeland. These lands include grasslands, deserts, shrublands, alpine areas, and well-stocked forests. They supply fiber for forest industries; minerals for energy and industrial development; and water for domestic and industrial consumption. They also provide recreation opportunities for millions of visitors each year.

Field programs and research work units of the Station are maintained in:

Boise, Idaho

Bozeman, Montana (in cooperation with Montana State University)

Logan, Utah (in cooperation with Utah State University)

Missoula, Montana (in cooperation with the University of Montana)

Moscow, Idaho (in cooperation with the University of Idaho)

Provo, Utah (in cooperation with Brigham Young University)

Reno, Nevada (in cooperation with the University of Nevada)